INSTRUCTION MANUAL

TYPE RM 529 OSCILLOSCOPE

MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

INSTRUCTION MANUAL

Serial Number 3199

TYPE RM 529 OSCILLOSCOPE

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070-466 1164

WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

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A list of abbreviations and symbols used in this manual will be found on page 6-1. Change information, if any, is located at the rear of the manual.

VERTICAL
INPUT
POSITION
RESPONSE
MAG
POWER
OC RESTORER
CALIBRATOR
HORIZONTAL
POSITION
DISPLAY
FOCUS
INTENSITY
MAG
DELAY
SCALE ILLUM
FIELD SHIFT
SYNC
TYPE RM 529 WAVEFORM MONITOR
TEKTRONIX, INC. PORTLAND, OREGON, U.S.A.

SECTION 1

CHARACTERISTICS

General Information

The Tektronix Type RM529 Waveform Monitor is a self-contained cathode-ray oscilloscope specifically designed for video-waveform monitoring at television transmitters and studio facilities. With this monitor, any portion of the television-signal waveform can be displayed on a 5-inch rectangular cathode-ray tube.

A frequency-response switch is included which enables the selection of several frequency-response characteristics including that characteristic recommended by the IRE Standards Committee for standardized pulse-level measurements.

An internal 30-kc amplitude calibrator provides 0.714-volt or 1.0-volt pulses for calibrating the vertical amplifier. The sweep system provides calibrated sweeps which eliminate the need for time markers.

Vertical Deflection System

Deflection Factor—Continuously variable from 120 mv to 1.5 v for 140 IRE units (6 cm of vertical deflection).

Frequency Response

Flat: Within ±1%, 60 cps to 5 mc; within ±3% to 8 mc (DC Restorer off).

IRE: 1958 Standard 23S-1, —20 db or 90% down at 3.58 mc.

Low Pass: —12 db or 75% down or more at 500 kc.

Chroma: 3.58 mc center frequency, 15% to 30% down at ±400 kc.

DC Restoration—Back-porch, does not affect the color-burst signal; can be modified for sync-tip restoration.

Input R and C—Approximately 1 megohm paralleled by 20 pf.

Signal Inputs—Two bridged 75-ohm signal inputs, either of which can be monitored.

Horizontal Deflection System

Calibrated Basic (X1) Sweep Rates—0.250 H/CM and 0.125 H/CM. X5 and X25 magnification is available for both sweep rates. See Table 2-1 in the Operating Instructions section.

Magnified-Sweep Accuracy—X5 is within 3%; X25 is within 5%.

Uncalibrated Sweep Rates—2-Line and 2-Field displays, special line and field displays for RGB.

Unblanking—DC used on all sweep rates with AC-coupled brightening pulse for Line Selector mode of operation.

Delay—Variable delay over entire field.

Staircase Input—Connector for accepting a staircase CPXR signal. Used in conjunction with certain color processing amplifiers.

Field Shift—Positive odd or even selection.

Trigger Selection

Internal—Derived from the A-input side of the vertical amplifier. Stable triggering on 200 mv to 1 volt or more peak-to-peak composite video signal.

External—Stable triggering on 250 mv to 1 volt or more peak-to-peak composite video signal.

Calibrator

Frequency—Approximately 30 kc.

Amplitude—0.714 v, accuracy adjustable; 1 v, ±1%. Provision is made for applying an external calibrator signal (0.25 to 1.6 v).

Cathode-Ray Tube

Tektronix Type T5290, flat-faced 4" x 5" rectangular crt operating at about 5.5 kv accelerating potential. Calibrated viewing area is 6 by 10 cm. Electrical beam rotator provides trace alignment. Phosphor: P31.

Graticule

Illumination—Variable edge-lighting.

Display Area—6 cm high by 10 cm wide. Three types of graticules, silk-screened on the back surface, are furnished as standard accessories (see Accessories list at the end of this section).

Power Supplies

DC Power Supplies—Electronically regulated to provide stable operation within the line-voltage operating range.

Line Voltage—115 v ±10% or 230 v ±10% rms. Refer to Power Transformer Connections in Section 2 for voltage conversion.

Line Frequency—50-60 cps.

Power Consumption—Approximately 80 watts at 115 v, 60 cps.

Fuse—1.25-amp slow-blow for 115 v; 0.6 slow-blow for 230 v.

Temperature

Cooling—Convection air cooled.

Ambient Temperature Range (Operating) — 0° C to +50° C.

Mechanical

Construction—Aluminum-alloy chassis.

Finish—Photo-etched, anodized front panel.

Dimensions—5¼" high x 19" wide x 20" deep overall. Fits standard 19" rack.

Net Weight—Approximately 27 pounds.

Accessories

Qty.	Description	Tektronix Part Number
1	3-wire to 2-wire power cord adapter	103-013
1	Light filter, green	378-525
1	Graticule, hybrid, % video modulation and 140 IRE units, composite, (silk screened)	331-150
1	Graticule, 100 IRE units, noncomposite, (silk screened)	331-146
2	Instruction manuals	070-466

SECTION 2

OPERATING INSTRUCTIONS

General

This section of the manual provides general operating information. Included is a brief description of the Type RM529 controls and a suggested first-time operation procedure.

Power Requirements

The regulated power supplies in the Type RM529 will operate with line voltages from 103.5 to 126.5 vac (115 vac ±10%) or from 207 to 253 vac (230 vac ±10%). The line voltage operating range for which your instrument is wired at the factory is indicated on a metal tag fastened to the rear panel near the power receptacle.

The power transformer is wound with two 115-volt primaries which are connected in parallel for 115-volt operation and in series for 230-volt operation. Fig. 2-1 shows the connections for both voltages. When the transformer connections are changed, the metal tag should be turned around so the back side becomes the front side. The unmarked side can then be marked with a pencil for the new operating voltage.

For maximum dependability and long life, the line voltage applied to the RM529 should be near the voltage indicated on the tag. If the line voltage exceeds the operating limits, or has a poor waveform (distorted sine waves), unstable power-supply operation may result. Check for proper line voltage and waveform before checking for other causes of unstable operation.

Cooling

The Type RM529 is cooled by convection air flow through the instrument. Allow two inches clearance at the sides and rear of the instrument for proper air circulation (see Rack-mounting section). Temperature of the circulating air should not exceed 50° C (122° F) for safe operation.

Radiation

To prevent high-voltage power-supply radiation of 30-kc fundamental and harmonic frequencies from affecting the Type RM529 display and adjacent instruments in the rack, it is important to keep the top and bottom dust covers in place.

FUNCTION OF FRONT-PANEL CONTROLS AND CONNECTORS

RELEASE Knobs

Locks the instrument securely into the rack or releases the instrument from the rack. To lock the instrument into the rack, turn the RELEASE knobs in a direction opposite to the arrows. To release the instrument so it can be pulled out of the rack on its slideout tracks, turn the RELEASE knobs in the same direction as the arrows.

VERTICAL Controls

INPUT

Four-position switch to select one of four input signals: internal calibrator, input A, input B or A—B differential.

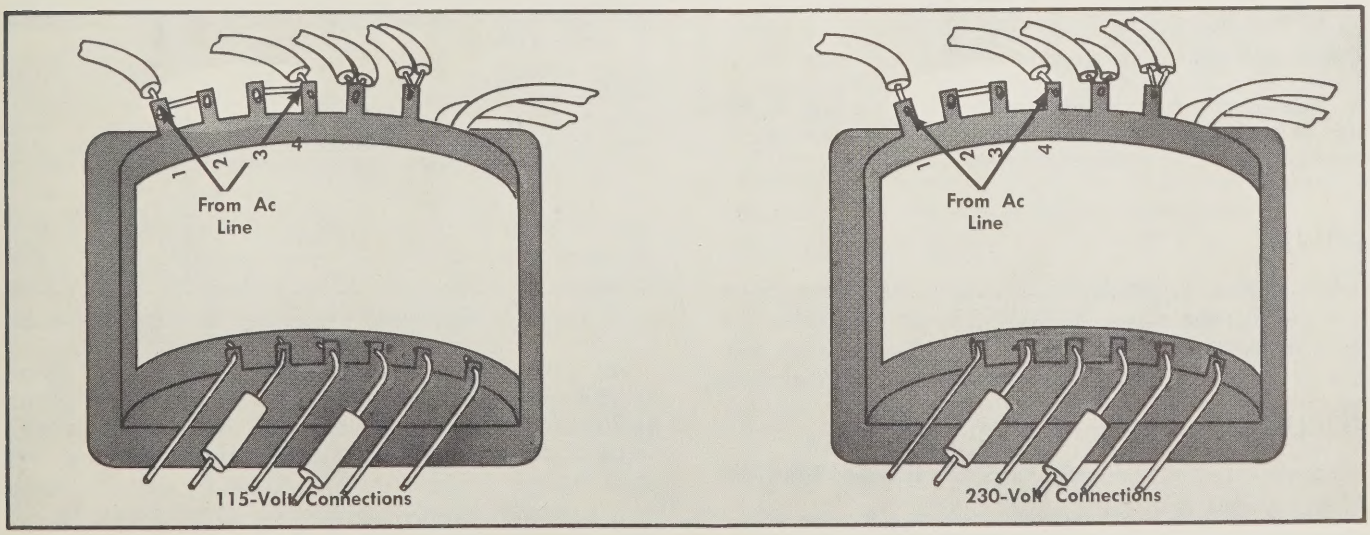


Fig. 2-1. Power transformer connections for 115- and 230-volt operation.

POSITION

Positions the trace vertically on the crt.

RESPONSE

Four-position switch to select the amplifier frequency-response characteristics as listed in Section 1 of this manual.

MAG Switch

Three-position switch to select the calibrated vertical gain settings of X1, X2 and X5.

VARIABLE (MAG)

Continuously varaible control with a minimum range of 4 to 1 to permit variable adjustment of gain between GAIN switch settings. When the VARIABLE control is set to CAL, the CAL neon turns on to provide a visual indication that this is the calibrated gain setting.

GAIN Adjustment

A screwdriver adjustment to reset the overall calibration of the instrument. (Corrects for long-term change in the high-voltage supply, which has the greatest effect on overall calibration of the instrument.)

DC RESTORER

Two-position lever switch for turning the dc restorer circuit off and on. This circuit is not a signal clamp. Instead, it is a keyed dc restorer circuit which stabilizes the blanking pulse back porch at a constant level on the crt despite changes in signal amplitude or average luminance. The dc-restoration time constant is sufficiently long so hum and tilt in the video signal will be displayed. This circuit eliminates dc drift of the vertical amplifier, making it unusually stable. There is no distortion, clipping, or degradation of the color-burst signal. The presence of the color-burst does not cause the base line to shift.

CALIBRATOR

Three-position lever switch that selects either 140 or 100 IRE units of signal according to the graticule markings, or selects an external calibration signal.

POWER

Two-position toggle switch for turning the instrument on and off. A neon above the POWER switch lights when the POWER switch is turned on.

FOCUS

Permits adjusting the beam to obtain a well-defined display.

INTENSITY

Controls brightness of the display.

SCALE ILLUM

Varies illumination of the graticule markings.

HORIZONTAL Controls

POSITION

A ten-turn control to position the display horizontally.

DISPLAY

A six-position switch to select 2 fields or lines of video signal, 0.125 H/CM, 0.25 H/CM, delayed line 0.125 H/CM or delayed line 0.25 H/CM.

The 2 FIELD or 2 LINE positions of the DISPLAY switch are used for general waveform monitoring. When the DISPLAY switch is set to 2 FIELD, the sweep operates at the frame rate, displaying about 2 fields. The FIELD SHIFT lever is used in conjunction with the 2 FIELD position to allow display of either the odd or even field. When the DISPLAY switch is set to 2 LINE, the sweep operates at one-third the line rate, displaying about 2 lines.

NOTE

The 2 FIELD position is the only position of the DISPLAY switch where a free-running trace can be obtained in the absence of a trigger signal. Thus, the 2 FIELD position is useful for determining whether the video signal is absent.

When the DISPLAY switch is set to .125 H/CM, horizontal sync timing is measured in terms of H (the time between horizontal sync pulses or the time from the start of one horizontal line to the start of the next line). When the (HORIZONTAL) MAG switch is set to X1, one complete horizontal line is displayed in a sweep length of 8 cm (see Fig. 2-2a). In addition, refer to Table 2-1 which lists the sweep-time relationship between H/CM and μsec/cm.

TABLE 2-1

(HORIZONTAL) MAG	DISPLAY Switch Setting	
	.125 H/CM*	.250 H/CM*
X1	0.125 H/cm	0.250 H/cm
	7.94 μsec/cm	15.9 μsec/cm
X5	0.025 H/cm	0.05 H/cm
	1.59 μsec/cm	3.18 μsec/cm
X25	0.005 H/cm	0.01 H/cm
	0.318 μsec/cm	0.635 μsec/cm

***Also applies to the DELAYED LINE settings of the DISPLAY switch.**

For pulse measurements at .125 H/CM, one cm equals 0.125 H. For example, in the NTSC signal specifications, 0.125 H is the minimum time interval between the leading edge of the horizontal sync pulse and the end of the color burst.

If the (HORIZONTAL) MAG switch is set to X5 when the DISPLAY switch is at .125 H/CM, the time-base sweep rate is 0.025 H/CM. This sweep rate is used, for example, to make horizontal sync pulse waveform measurements such as those shown in Fig. 2-2b.

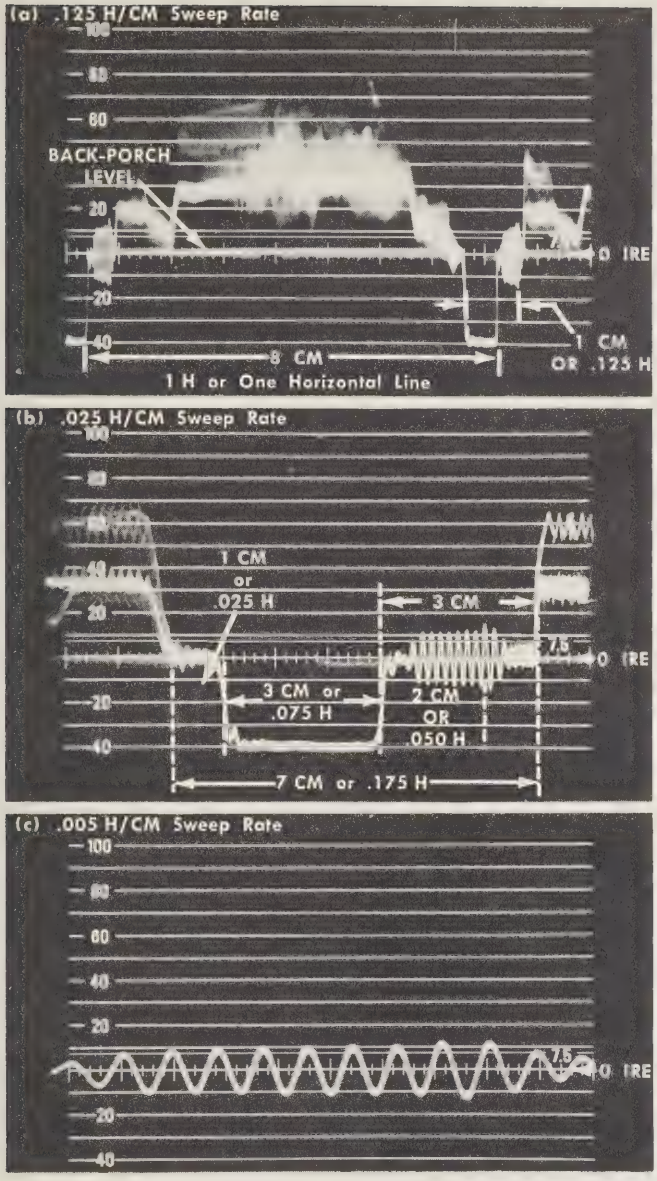


Fig. 2-2. Using the .125 H/CM position of the DISPLAY switch, in conjunction with the MAG switch, to make horizontal line sync pulse measurements. (a) MAG switch set to X1 or 0.125 sweep rate, (b) MAG switch set to X5 or 0.025 H/CM, and (c) MAG switch set to X25 or 0.005 H/CM sweep rate.

If the (HORIZONTAL) MAG switch is set to ×25 when the DISPLAY switch is at the .125 H/CM position, the sweep rate is 0.005 H/CM. This sweep rate is useful for measuring the rise and fall time of the horizontal sync pulses, to count the cycles of color burst (see Fig. 2-2c) and to examine portions of a complete line.

The .25 H/CM position of the DISPLAY switch is another calibrated sweep rate which is useful for making horizontal line and sync pulse waveform measurements. In the X1 position of the (HORIZONTAL) MAG switch approximately 2½ horizontal lines are displayed. Table 2-1 lists the sweep-time relationship between H/cm and μsec/cm for each MAG switch position.

When the DISPLAY switch is set to either of the DELAYED LINE positions and the DELAY control is used, it is possible to range into the top of the picture to examine any one or two lines, depending on whether the DISPLAY switch is set to the .125 H/CM DELAYED LINE or .25 H/CM DELAYED LINE position. Also, the DELAY control can be set so the portion of the vertical blanking pulse which may contain vertical-interfield test signals can be examined in detail. The .25 H/CM DELAYED LINE position, in particular, is useful for observing sine² pulses.

The range of the DELAY control is such that any portion of an odd or even field can be examined. The odd or even field is selected by means of the FIELD SHIFT switch. A special bright-up circuit in the Type RM529 increases the crt writing rate in either of the two DELAYED LINE positions.

MAG

Three-position switch to select sweep magnification ratios of X1, X5, and X25 for all positions of the DISPLAY switch.

DELAY

Ten-turn variable delay control for starting the sweep at the beginning of any selected line in the field so that particular line can be examined in detail. Used in conjunction with all positions of the (HORIZONTAL) MAG and FIELD SHIFT switches when the DISPLAY switch is set to DELAYED LINE .125 H/CM or .25 H/CM.

FIELD SHIFT

Two-position lever switch to select either the odd or even field. Used in conjunction with the DELAYED LINE and 2 FIELD positions of the DISPLAY switch.

SYNC

Two-position lever switch to select either internal or external sync sources.

REAR-PANEL CABLE CONNECTIONS

VIDEO INPUT A, VIDEO INPUT B

Two pairs of signal input coax connectors are provided. These are: VIDEO INPUT A and VIDEO INPUT B. These video inputs are designed for high-impedance loop-through, compensated for 75-ohm systems. Bridging capacitance is approximately 20 pf.

If the second connector of each pair is not used, it can either remain unused or it can be a convenient place for terminating the line with a 75-ohm termination.

EXT NEG SYNC INPUT

A pair of coax connectors marked EXT NEG SYNC INPUT is provided on the rear panel to couple external sync signals to the Type RM529. This input is a high-impedance loop-through connector and is compensated for 75-ohm systems. Bridging capacitance is about 20 pf. To select external sync, set the SYNC switch to the EXT position.

EXT CAL INPUT

The pair of connectors marked EXT CAL INPUT, located on the rear panel, is provided to couple external calibration signals to the instrument. The connectors are connected in parallel to couple the signal in and out of the instrument. To select the external calibration signal, set the INPUT switch to CAL and the CALIBRATOR switch to EXT.

VIDEO OUTPUT

A single VIDEO OUTPUT connector is provided for driving a picture or line monitor. The signal available at this connector, when connected into a 75-ohm load, is approximately the same amplitude as the signal applied to the Type RM529.

Added to the VIDEO OUTPUT signal is a line intensifying pulse. This pulse is approximately 0.2 volt in amplitude or about 10% of the VIDEO OUTPUT signal when the input video signal is 1 volt.

The line intensifying pulse is generated only when the DISPLAY switch is set to DELAYED LINE .125 H/CM or DELAYED LINE .25 H/CM. The DELAY control is used to select the line(s) that is to be examined in detail on the Type RM529 crt and the picture monitor. The line intensifying pulse brightens the selected line(s) on the picture monitor for easy identification.

J501 Connector

A 9-pin female connector J501 is provided to connect an external staircase signal to the Type RM529. Fig. 2-3 shows how to connect the signal and remotely actuate relay K385.

When K385 is actuated and the DISPLAY switch is set to any position, the sweep length is reduced to about three cm. Thus, when a 20-cps staircase signal of correct amplitude (about 12 volts overall amplitude) is applied through pin C of J501, the display is positioned in accordance with the staircase output from a color processor.

Cable Lengths

Use cable lengths which are long enough to allow the instrument to slide out of the rack or console on the slide-out tracks with cables connected.

FIRST-TIME OPERATION

To place the instrument in operation for the first time, the following procedure is suggested:

1. Connect the instrument to a source of power specified by the metal tag located near the power connector.

2. Set the front-panel controls as follows:

POWER	On
FOCUS	Centered
INTENSITY	2/3 rotation clockwise
SCALE ILLUM	As is

VERTICAL Controls

INPUT	CAL
POSITION	Centered
RESPONSE	FLAT
MAG	X1
VARIABLE (MAG)	CAL
DC RESTORER	ON
CALIBRATOR	F.S.

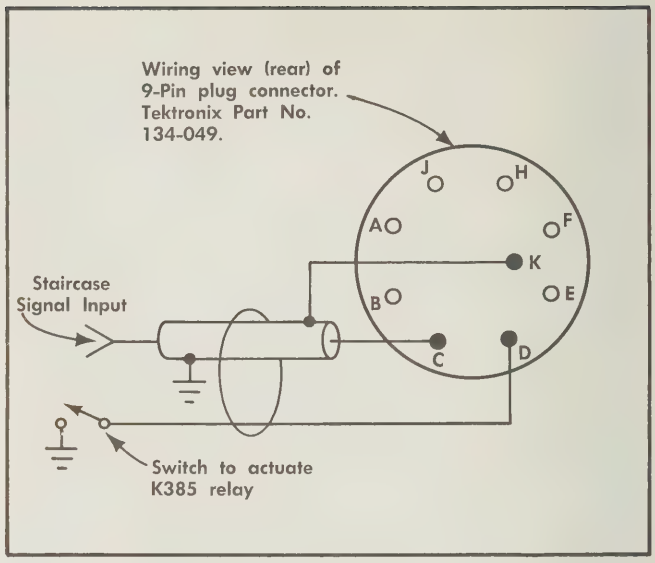


Fig. 2-3. Illustration showing how to apply the staircase signal to the Type RM529 connector J501 and actuate relay K385.

HORIZONTAL Controls

POSITION	Centered (five full turns from either end)
DISPLAY	2 LINE
MAG	X1
DELAY	As is
FIELD SHIFT	ODD or EVEN
SYNC	INT

3. After the instrument has warmed up a few minutes, adjust the INTENSITY control for adequate brightness of the square-wave calibrator waveform.

4. Adjust the (VERTICAL) POSITION control to center the display.

5. Adjust the FOCUS control to obtain a sharply defined display.

6. To observe other waveforms, connect a video signal to either of the VIDEO INPUT A or B connectors and set the INPUT switch to the appropriate position.

To observe an external calibration waveform, connect the calibration signal from the external source to the EXT CAL connector. Place the INPUT switch to CAL and set the CALIBRATOR switch to EXT.

Crt Beam Rotator

If the trace does not coincide with the graticule lines, the CRT BEAM ROTATOR R655 needs to be adjusted. To adjust the control, proceed as follows:

1. Perform steps 1 through 5 in the First-Time Operation procedure.

2. Set the CALIBRATOR to .714 and the DISPLAY switch to 2 FIELD.

3. Adjust the CRT BEAM ROTATOR control so the bottom trace of the calibrator pulses coincides with the 0 IRE graticule line. Location of the control can be found by referring to Fig. 5-11 on a fold-out page in the Calibration section of this manual.

GAIN Adjustment

A front-panel GAIN screwdriver adjustment is provided to correct for long-term change in the high voltage supply. A change in the supply voltage will affect both the vertical and horizontal calibration.

To check calibration, check the vertical-amplifier calibration first as follows:

1. Perform steps 1 through 5 in the First-Time Operation procedure, on page 2-4.

2. Check that 140 IRE units of vertical deflection is obtained. If the deflection is not 140 IRE units, adjust the GAIN control to obtain proper deflection.

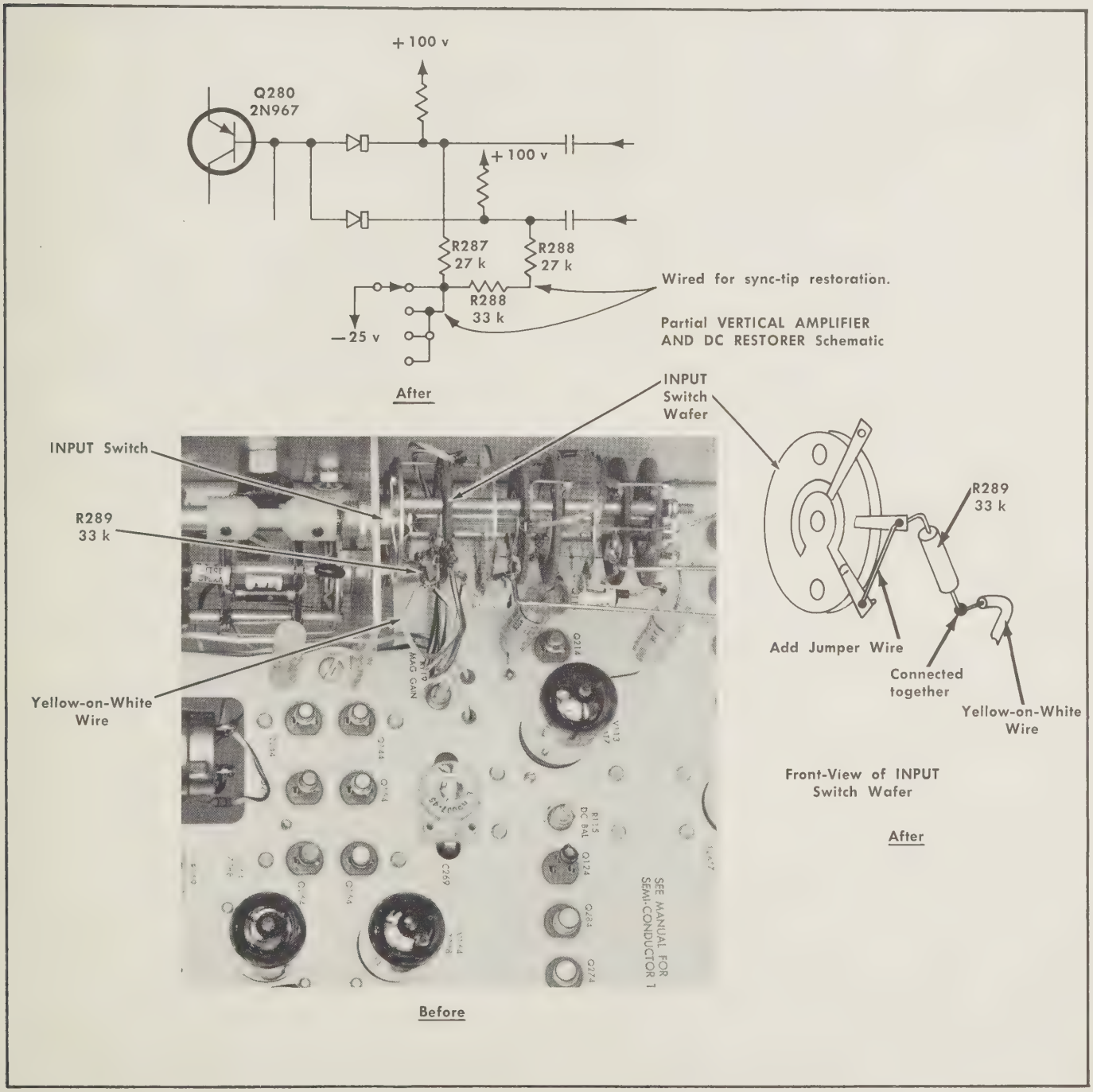


Fig. 2-4. Modification for sync-tip restoration.

3. If desired, the horizontal calibration can be checked by performing steps 17 and 18 in the Calibration section of the manual. If the HORIZ GAIN R568 or C481 are adjusted, then step 19 should also be performed to fully calibrate the horizontal sweep rates.

MODIFICATIONS

Introduction

Here are five modifications that make the Type RM529 satisfy certain studio conditions. The first four can be made in the field but the last one is more complex and therefore is normally done at the factory.

1. Changing To Sync-Tip Restoration

To change the Type RM529 circuitry so sync-tip restoration can be used instead of back-porch clamping:

a. Unsolder the yellow-on-white wire (refer to Fig. 2-4) and R289 from the INPUT switch contact. Leave the wire and resistor leads connected together.

b. Solder a jumper wire between the two contacts on wafer 1F of the INPUT switch as shown in Fig. 2-4.

2. Changing to DC Input Coupling

Sometimes it is necessary to observe the demodulated output from a television transmitter using a dc-coupled oscilloscope. For this purpose the RM529 can be dc coupled, using VIDEO INPUT A, as follows:

a. Refer to the Vertical Amplifier and DC Restorer schematic at the back of the manual and the partial schematic shown in Fig. 2-5.

b. Remove C104 and C204 (0.1 μf capacitors) and solder jumper wires in their place.

c. Disconnect the braided "ground" lead that connects from the J201/J202 connector outer conductor to the INPUT switch contact.

d. Remove R201 from its location on the INPUT switch. Connect R201 between J201/J202 connector outer conductor and ground.

e. Connect one of the removed 0.1-μf capacitors between J201/J202 connector outer conductor and the INPUT switch contact (where one end of R201 was formerly connected).

f. Locate the jumper wire going from J201 connector center conductor to the INPUT switch contact. Disconnect this jumper at J201 and cut off about 2" to shorten it. Connect the second 0.1-μf capacitor in series between the shortened end of the jumper lead and the center conductor of J201.

NOTE

After completing this modification, the DC RESTORER is automatically off when the INPUT switch is set to A.

3. Shortening the Sweep

To shorten the sweep duration so the Type RM529 can be used to display staircase signals having more than three steps, decrease the value of the 1.5-megohm resistor R501.

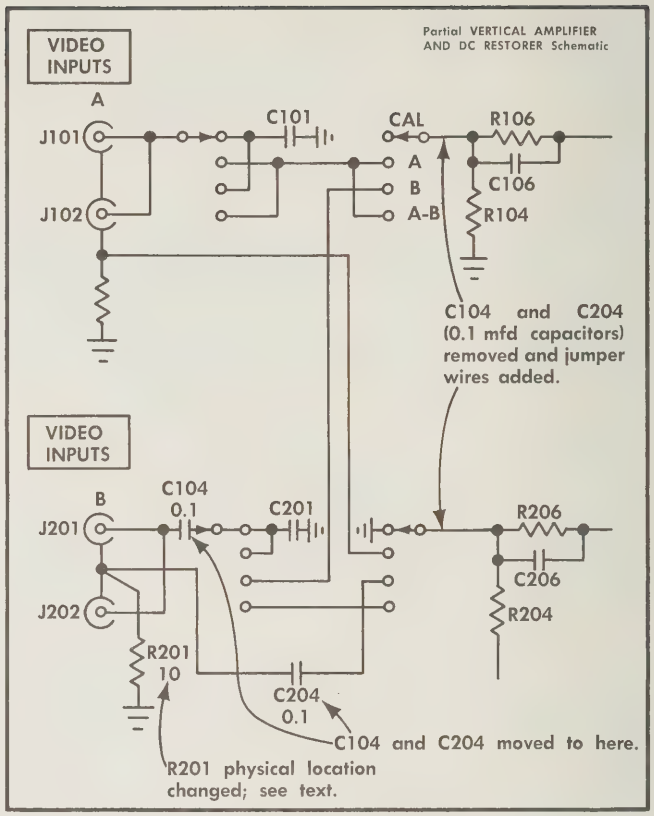


Fig. 2-5. Modification to dc-couple VIDEO INPUT A.

At the same time, decrease the value of R502 (374 k) to center the display on the screen. These resistors are located in the grid circuit of V514. Refer to the Sweep Generator and Horizontal Amplifier diagram at the back of the manual.

4. Changing the Sweep Repetition Rate

Since the field rate in some countries differs from the 30-cps rate used in the United States, the Type RM529 must be modified to operate at the different rate.

To modify the instrument to operate at a longer time per field (slower sweep repetition rate) than 30 cps, increase the value of C483. For less time per field (faster sweep repetition rate), decrease the value of C483 by substituting a smaller value. Refer to the base circuit of Q483 on the Sweep Generator and Horizontal Amplifier diagram at the back of the manual to locate C483 on the schematic.

5. Changing to 4.4-mc Chroma Response

In countries using a 4.4-mc color-burst frequency, the Type RM529 must be modified and adjusted to pass this center frequency when the RESPONSE switch is set to CHROMA. This modification is much more complex and is therefore normally performed in the factory at the request of the purchaser at the time the instrument is ordered.

When the factory modification is made, prepared insert sheets showing the changes that were made are inserted in the manuals accompanying the modified instrument. For this reason, no further information is provided in this section of the manual.

SECTION 3

CIRCUIT DESCRIPTION

General Information

The Type RM529 Waveform Monitor circuits contain both vacuum tubes and transistors. Portions of both the vertical and horizontal systems contain amplifiers with special feedback for gain stability independent of tubes or transistors. Several multivibrators in the trigger and horizontal systems provide precise display triggering. Refer to the block and circuit diagrams at the back of this manual during the following circuit descriptions.

All connectors are rear-panel mounted. Four of the input circuits are 75-ohm coaxial loop-through; two VIDEO INPUTS, EXT NEG SYNC INPUT and EXT CAL INPUT. The Staircase Input J501, is a special nine-pin socket (see Staircase Input discussion in Section 2 for mating connector). The VIDEO OUTPUT coaxial jack has a 75-ohm unbalanced output impedance.

BLOCK DIAGRAM

The Vertical INPUT switch selects either of two video signals, or the A signal minus the B signal, or the CALIBRATOR signal, (the calibrator signal can be from an external source) and applies it to the input of the Vertical Amplifier. The Preamplifier supplies the signal to both the Response Filters and the Video Output Amplifier. The Response Filter passes the signal on to the Output Amplifier and to the crt deflection plates. The Output Amplifier also supplies the signal to the Keyed Dc Restorer. The Video Output Amplifier supplies an ac coupled signal to the VIDEO OUTPUT jack (with an open circuit gain of 2, and 75-ohm loaded gain of 1 referred to the video input), and an ac coupled signal to the Trigger Generator.

The Trigger Amplifier and Shaper regenerates the horizontal sync pulses so their shape and amplitude is always the same. Plus and minus regenerated horizontal sync pulses are available for operating the Keyed Dc Restorer of the Vertical Amplifier. Minus H pulses are used when displaying video, and plus H pulses are used when displaying the Calibrator.

The Keyed Dc Restorer holds the display steady at the video back porch level or the negative level of the internal calibrator. The circuit operates by controlling the dc level of the Vertical Amplifier minus input. The video input signals are ac coupled, but the Vertical Amplifier is dc coupled. The dc restorer virtually eliminates display shift with change in signal amplitude, but allows hum or tilt to be observed because response time is slow enough to allow these to be seen.

The Trigger Amplifier and Shaper —H signal is used by the Sweep generator when the display is of a line nature (undelayed). The +H signal does not go directly to the Sweep Generator, but to the Field Selector portion of the Trigger Generator. It first passes through the Vertical Sync Separator, and then to both the Even Field Recognition circuit and the Field Trigger Generator Q375-Q385. The Field Trigger Generator triggers the Sweep Generator directly for field displays (undelayed), and through the Delay Generator for delayed Field displays.

The Sweep Generator triggering source and sweep rate is set by the front-panel DISPLAY switch. Triggers are received by the Sweep Gating Multivibrator that allows the Sweep Generator to run and drives the Unblanking Amplifier to turn on the crt beam at the time of the sweep. The Unblanking Amplifier also sends a brightening pulse to the crt and the VIDEO OUT jack during delayed line modes. The Sweep generator drives both the Horizontal Amplifier and the Staircase Amplifier. The Staircase Amplifier is inserted "between" the Sweep Generator and the Horizontal Amplifier when external control (through J501) switches the Sweep Generator function to view the red, blue and green portions of a color studio camera.

The CRT Circuit and Calibrator contain the crt high voltage power supply. A portion of the power supply circuit forms the calibrator signal at the 30 kc rate of the high voltage oscillator. An external calibrator signal can be substituted for the internal signal.

VERTICAL AMPLIFIER

The Video input circuits to the Vertical Amplifer are shown in simplified form in Fig. 3-1. The 10-ohm resistor in Fig. 3-1A is optional, but necessary in the event there is any ac potential difference between the input coax and the RM529 chassis. It presents any cable-to-chassis signal differentially to the Vertical Amplifier so the signal will not become part of the display. (Any signal on the outside of the braid of a coax is also on the center conductor, but with the same polarity. The equal signals are applied to the + and — input terminals, and cancelled by the differential rejection characteristics of the Vertical Amplifier.) The A—B input of Fig. 3-1B does not use the 10-ohm resistors because the cables are likely to have the same unwanted information. Since the unwanted information appears on both center conductors, it is presented to the Vertical Amplifier in differential form and cancelled.

Operating With Dc Restorer Off

Operation of the vertical amplifier will be described first with the Dc Restorer turned off.

Both the + and — input grids of V113 see 1 megohm return to ground. The input signals are ac coupled to the input grids through C104 and C204. The rest of the Vertical Amplifier is dc coupled.

Preamplifier. The Preamplifier consists of the two input cathode followers V113A and V113B and a two-transistor amplifier, Q114 and Q214. The Preamplifier is shown in simplified form in Fig. 3-2A. The cathodes of V113 return to the same constant current circuit to which the emitters of Q114-Q214 return. The MAG control between emitters of Q114-Q214 couples the signal between emitters, causing both sides of the amplifier to have an output signal when only one input receives a signal.

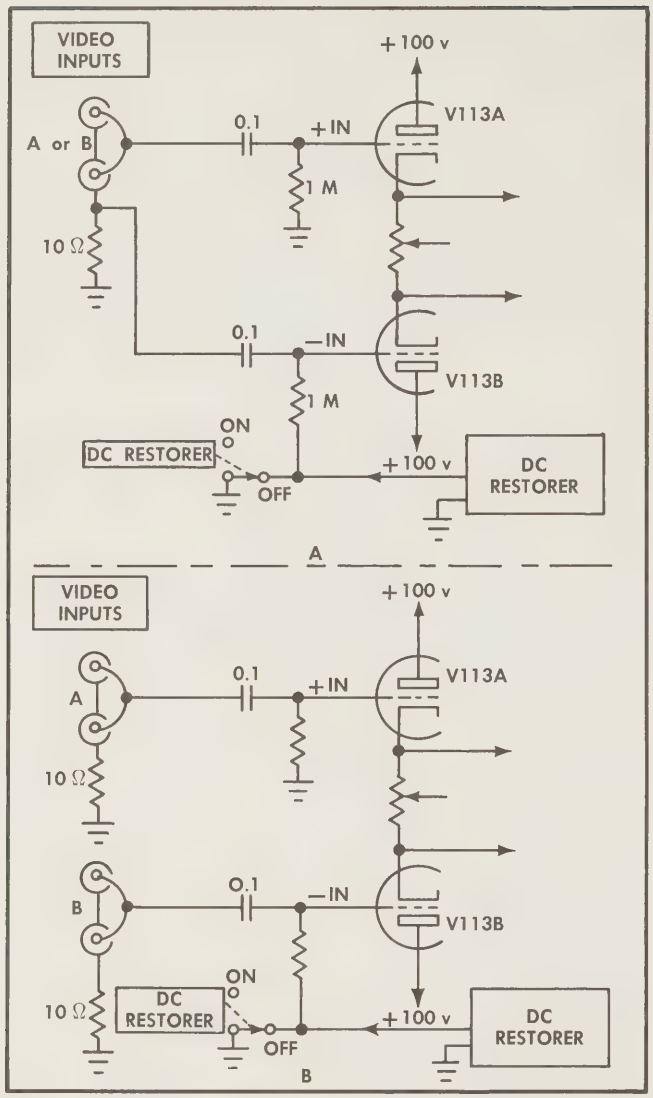


Fig. 3-1. Simplified Vertical Amplifier input circuits.

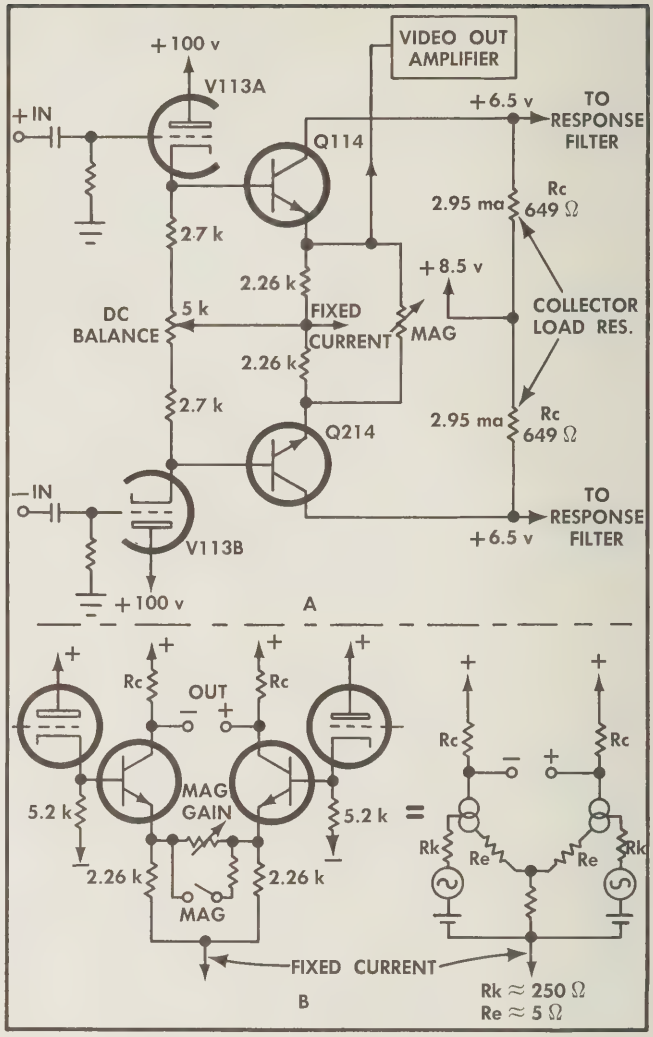


Fig. 3-2. Simplified circuit. See text.

The tubes serve basically as impedance transformers, changing the 1-megohm input resistance to about 400 ohms to drive each transistor base. The cathode return resistors, called "long-tail" are about 20 times the cathode follower output impedance, so therefore do not attenuate the signal significantly. Each cathode follower passes about 93% of the input signal to the following transistor base.

The 2.26 K emitter resistors would normally be very degenerative and would thus keep the stage gain very low. However, the MAG resistance between the two emitters also couples the signal from one side to the other. Fig. 3-2B shows the MAG control signal path. If the MAG resistor were made zero ohms, the input signal to one transistor base would divide equally between the two halves of the stage. Fig. 3-2B shows the internal emitter resistances in series, indicating that MAG = zero ohms degeneration to one side of the amplifier is the emitter resistance of the other side of the amplifier, causing both sides of the amplifier to have gain. The 2.26 K emitter return resistors are many times greater than the emitter internal resistance, and therefore do not attenuate the signal when the MAG resistance is low. The actual minimum MAG resistance is about 590 to 600 ohms between emitters setting the push-pull output signal equal to about 2 times the single ended input signal.

A typical single input signal will cause the following action (assume the MAG resistance to be 600 ohms): Q114 base is driven in the positive direction 1 volt and its emitter follows it nearly 1 volt. The 600 ohm resistor allows the emitter current to increase and the emitter voltage to follow the base voltage nearly one volt. The increased forward bias of Q114 is about 0.02 volt. The signal current is essentially 1.66 ma greater than the static current. The only source for the signal current is the emitter of Q214; therefore both transistors receive the same signal current for a single input signal, but of opposite polarity. The result is that both 649 ohm collector resistors have a 1.66 ma signal current. The collector of Q114 goes negative, and the collector of Q214 goes positive producing a push-pull output signal about 2.2 volts peak-to-peak. Since the 649 ohm collector load resistors have equal and opposite current changes, the voltage at their center does not change. A common-mode signal reaching the Preamplifier, would

change the voltage at the junction of the 649 ohm collector load resistors and degrade the common-mode rejection of the amplifier except for the Constant Current Stage.

The high frequency gain of the Preamplifier is adjusted to equal the low frequency gain by making the RC time constant of the emitter circuit equal to the RC time constant of the collector circuit. The cathode followers' output impedance allows the "Miller" capacitance of the transistors to affect the high frequency response. To minimize the Miller effect, the transistor stage is "neutralized" by C113 and C213. The variable capacitors (C118B and C118C) across the MAG resistors R118B and R118C permit the Preamplifier frequency response to be properly adjusted. There is no need for a variable capacitor across R118A due to wiring stray capacitance.

In the event of minor differences in bias of the input cathode followers (and the resultant output voltage difference), the DC BAL control (R115) is set to create a compensating change in current in the cathode return circuit. The DC BAL control final setting is correct if the trace does not shift when changing the MAG switch position (with the Dc Restorer OFF).

The high impedance of the Preamplifier transistor collectors allows the output voltage to be varied a slight amount without significant change in current. The VAR DC BAL control slightly alters the voltage balance of the Preamplifier output to allow the Output Amplifier VARIABLE control (between emitters of Q144-Q244) to be adjusted without shifting the trace position.

Constant Current Stage. The Constant Current stage cancels any push-pull output from the Preamplifier in the event both input leads receive equal amplitude—equal polarity signals. The circuit causes the voltage of the constant current leads of Fig. 3-2 to shift and follow any common mode input voltages. (The high collector resistance of Q114 and Q214 prevents any change in the Preamplifier output voltage.) Fig. 3-3 shows simplified connections between the Constant Current stage and the Preamplifier. Assume both input leads go positive. The result is that both 649 ohm collector load resistors receive an increase in current. The increased current pulls down on R121. R122 divides the change to the base of Q124. Q124 base goes negative and causes its collector to go positive an amount equal to the original common-mode signal, cancelling its effect and returning the current in the 649 ohm collector load resistors to the original value. The input cathode followers' negative supply is the same as Q114-Q214 negative supply to assure signal linearity in the event of common mode signal cancellation by Q124.

The principal reason for keeping the common mode currents out of the Preamplifier is that even though the currents may be equal, the collector load resistors may not be precisely equal, and equal currents would generate unequal output voltages. The circuit does stop the Preamplifier output from moving + or — with common mode signals.

Response Filters. The frequency response of the overall monitor is altered for special purposes by the RESPONSE switch and its filters.

The FLAT position of the RESPONSE switch gives the widest bandwidth, with a direct connection from the Preamplifier to the Output Amplifier.

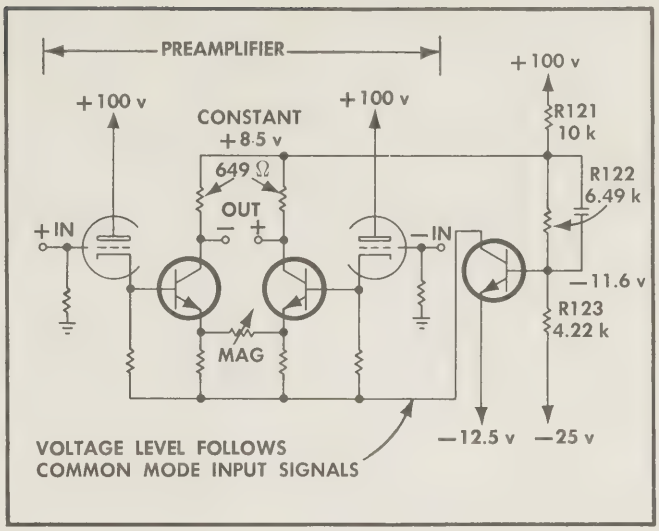


Fig. 3-3. Simplified Constant Current stage connections to Preamplifier.

The IRE position of the RESPONSE switch inserts components that cause the overall monitor bandwidth to be low-pass to agree with the 1958 Standard 23S-1.

The LOW PASS position of the RESPONSE switch inserts components that alter the overall response so that it is about —12 db down at 500 kc.

The CHROMA position of the RESPONSE switch inserts a critically coupled transformer between the Preamplifier and the Output Amplifier, making the overall monitor bandpass about 800 kc centered at 3.58 mc. The dc level at the input of the Output Amplifier is maintained by connecting the center of the primary and secondary windings together at a "cold" rf point. The Chroma filter is the only filter requiring adjustment during calibration. The overall adjustment of the vertical amplifier is made with the RESPONSE switch in the FLAT position.

Output Amplifier. The Output Amplifier includes two sets of push-pull amplifiers, each with variable emitter coupling to vary the gain. The first amplifier is Q144-Q154 and Q244-Q254. The second amplifier is driven by the first, and is a combination of transistors and tubes giving a large voltage output swing.

The driver portion of the amplifier has negative feedback from the collector of Q154 to the emitter of Q144 (and from Q254 to Q244). The negative feedback makes the input impedance at the base of Q144 very high and the output impedance at the collector of Q154 quite low. The high input impedance prevents loading of the response filters. The low output impedance is needed to drive the base of Q164 (and Q264). R154 is the negative feedback path and is also the connector load resistor for Q154. See Fig. 3-4.

The VARIABLE gain control (concentric with the MAG switch) varies the emitter-to-ground degeneration between Q144 and Q244 to vary the overall vertical amplifier gain by a 4:1 ratio. The VARIABLE control mechanically switches R241 into the circuit in the CAL position, and out of the circuit (SW240 closed) when not in the CAL position. If the

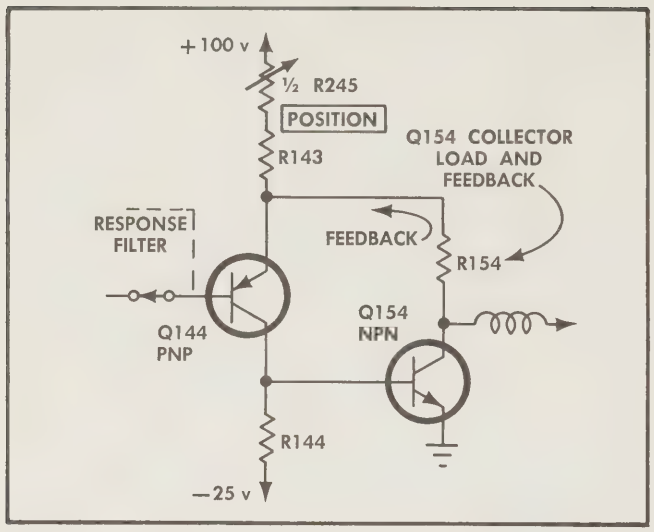


Fig. 3-4. Simplified one-half output driver stage.

VARIABLE control is counterclockwise at lower than calibrated gain, clockwise rotation can increase the monitor gain so it is greater than normal. Then as the clockwise end of rotation is reached and the control is rotated to snap into the CAL position, the overall gain drops about 70% as R241 is switched into the circuit. At the same time a second part of SW240 closes and turns on the front-panel CAL neon lamp.

The output driver signal is coupled to the base of Q164 (Q264) of the output cascode amplifier. The combination of a transistor (supplying cathode drive) and a tube not only gives stable gain but also gives the wide voltage output swing that only a tube can provide. The output cascode stage also has emitter-to-emitter degeneration used to adjust the overall Vertical Amplifier gain to match the crt deflection factor. The emitter circuit also contains the HF COMP capacitor that permits the output stage high frequency gain to be adjusted a bit higher than the low frequency gain. The adjustment helps make the bandpass correct for the FLAT position of the RESPONSE switch. The Dc Restorer circuit placed across the output stage emitter degeneration circuit does not affect the stage gain because R149 and R249 in series are about 40 times larger than the emitter coupling resistance. (The DC Restorer will be discussed later in this section.)

While reading the following description of the cascode stage operation, keep in mind that (1) a transistor's emitter follows its base, just as a tube's cathode follows its grid—if the return circuit is a higher impedance than the internal emitter or cathode impedance, and (2) a transistor's collector is a quite high impedance, as high as the plate impedance of some triode tubes.

A signal that drives the base of Q164 in the positive direction causes several simultaneous circuit changes. The emitter voltage of Q164 follows the base voltage, with emitter voltage change about 2 percent less than base voltage change, offset by normal silicon transistor bias. The positive swing of Q164 emitter drives the grid voltage of V164 positive the same amount, and the cathode of V164 follows, lagging its grid by about 20 percent. The 20 percent positive bias occurring in V164 as a result of cathode follower action increases plate current, and the consequent plate current increase causes the output plate voltage to drop in the negative direction an amount determined by R162 and Ohm's Law.

Push-pull signals that drive the bases of Q164-Q264 drive the two halves of the output stages equally. (The degenerative action of the resistors between emitters is one half what it would be if only one base received a signal.) The signal voltages at Q164-Q264 bases cause plate current changes of V164 and V264 to be about 3.3 ma per centimeter of spot deflection each, producing a push-pull voltage output to the crt deflection plates of about 20 volts per centimeter. The peaking coils in each plate circuit compensate for deflection plate capacitance, and aid in obtaining flat frequency response of the Vertical Amplifier.

Positioning the crt display (with Dc Restorer OFF) is by current injection into the emitter circuits of Q144-Q244 through R143 and R243. The POSITION control (R245) does send current toward the cascode output stage emitters, but this current does not affect the display position so long as the Dc Restorer is off. Voltage changes at the emitters of Q164 and Q264 do not significantly affect the positioning circuit because the two germanium diodes D271-D272 limit the voltage difference between R149-R249 junctions with R148-R248.

Operation With Dc Restorer On

The Dc Restorer provides an automatic dc positioning voltage to the —input grid of V113B. The source of dc positioning voltage is the signal in the emitter circuit of the output cascode stage. Since the signal is usually composite video (sometimes it is the CALIBRATOR), and since the Dc Restorer positions the crt display firmly around the level of the composite video horizontal sync pulse back porch, the restorer must "look" at the video only at the correct time. The Dc Restorer is keyed by the horizontal trigger system to sample the video back porch for about 0.4 μsecond, and remember the dc level until the next horizontal sync pulse occurs.

When the Dc Restorer is on, the positioning circuit in the Output Amplifier works differently. The current injection into the emitter circuit of Q144-Q244 (described previously) that changes the display position, also changes the dc level of information into the Dc Restorer. The result is that the effect of positioning current into Q144-Q244 is canceled by the Dc Restorer. A second current injection path does permit the POSITION control to operate. The second path is through R148 and R248 into the input of the Dc Restorer Comparator where the positioning current changes the dc level of the composite video at the point where it is "looked at" by the Restorer.

Keyed Dc Restorer. The Keyed Dc Restorer includes circuits diagrammed with the Vertical Amplifier: the Dc Restorer Comparator, the Blocking Oscillator, and the Restorer Cathode Follower. Voltages and waveforms on the Vertical Amplifier diagram were taken with the Dc Restorer on. The simplified diagram of Figs. 3-5, 3-7 and 3-8, and waveforms of Fig. 3-6 will help during the following discussion of the Dc Restorer operation.

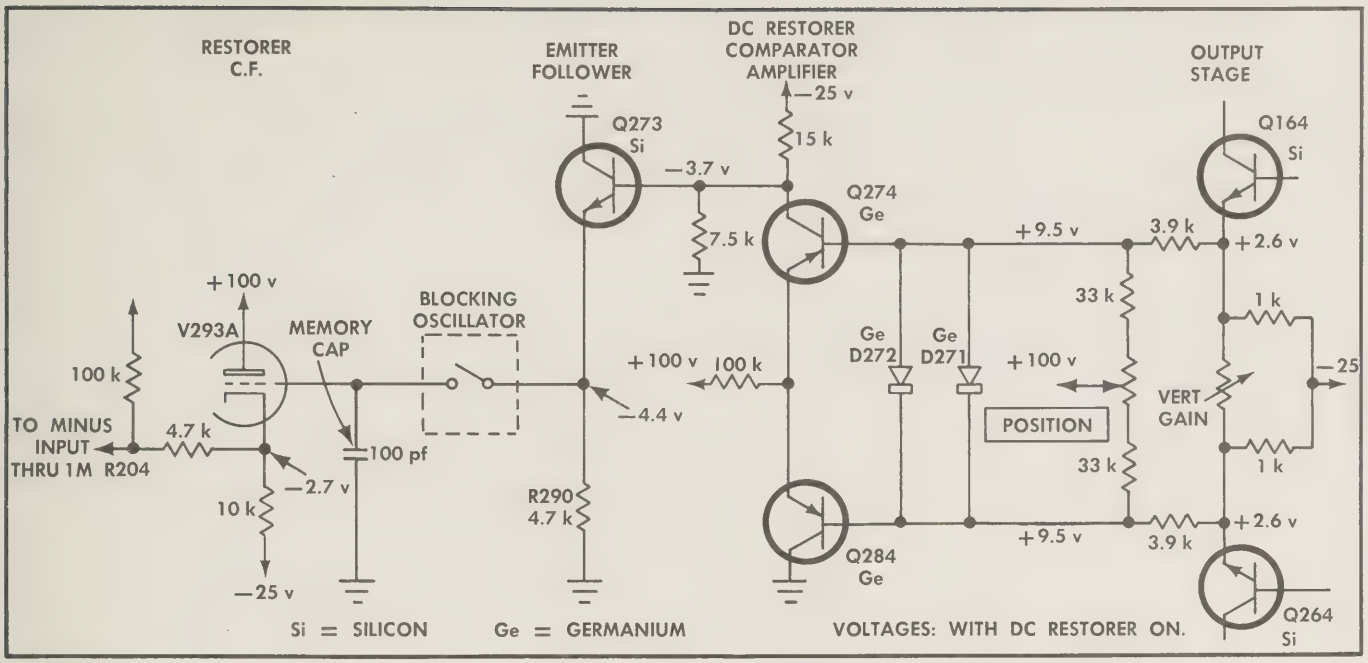


Fig. 3-5. Simplified keyed Dc Restorer circuit. See text.

The Dc Restorer Comparator is a dual input single output amplifier that amplifies a small part of the composite video that is normally near the crt screen center. The signal peaks are limited by parallel back-to-back germanium diodes D271-D272. See Fig. 3-5. One of the two diodes conduct whenever the voltage across them exceeds between 0.2 and 0.3 volt. When the diodes are not conducting, the Comparator Amplifier bases are fed pushpull signals from the two emitters of the Output Amplifier cascode stages. When a diode is conducting, the two bases of the Comparator Amplifier are essentially shorted together, and there is no gain. When the signal at the base of Q274 goes negative (and the signal at the base of Q284 goes positive) D271 conducts. The opposite polarity signal causes D272 to conduct. The peak-to-peak signal input to the Comparator Amplifier is therefore limited to about 0.45 volt. The Comparator Amplifier output signal is typically 4.2 volts peak-to-peak at the emitter of the Emitter Follower Q273. The Comparator functions in the same manner as the differential Preamplifier previously described, except there is just one output lead. Fig. 3-6D shows the signal as it enters the Blocking Oscillator. The other waveforms of Fig. 3-6 are discussed with the Blocking Oscillator below.

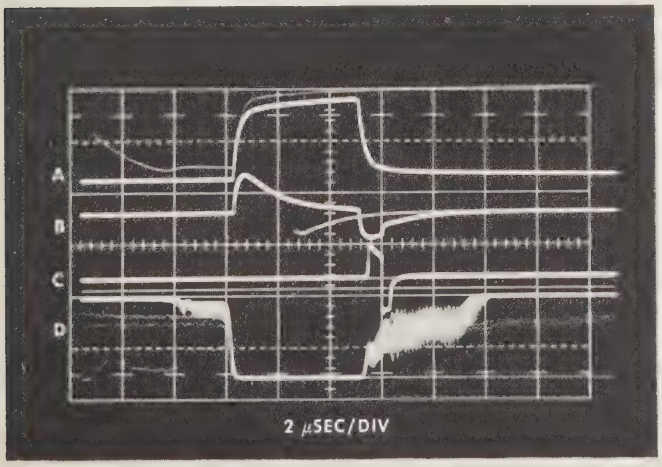


Fig. 3-6. Time-coincident waveforms of keyed Dc Restorer. See text.

Blocking Oscillator. The Blocking Oscillator is normally biased to cutoff by current through R282 and D282. A negative pulse applied to the base of Q280 will cause it to conduct and go through one cycle of oscillation. The negative pulse arrives at the base of Q280 through a diode switching network from the Trigger Shaper (diagrammed with the Trigger Generator).

Assume the vertical INPUT switch is at A, as shown in Fig. 3-7. The diode switching circuit then reverse biases D285 about 45 volts and reverse biases D286 about 1 volt. Regenerated horizontal sync pulses arriving at C285 and C286 have a peak-to-peak amplitude of about 8 volts. Thus the —H pulse will not cause D285 to conduct, but the +H pulse will cause D286 to conduct at the end of the pulse as it goes negative. C286 charges almost the full 8 volts of the +H pulse rise, and then causes the cathode of D286 to fall about 7 volts. The base of Q280 does not fall fully 7 volts because of the base-to-emitter low impedance at the time of turn on.

The Blocking Oscillator turns on at the time the composite video horizontal sync pulse ends and starts toward the back porch level. The back porch level occurs about 0.25 μsec later, so the blocking oscillator does not sample the video at the time of turn on. As Q280 conducts, the L/R time constant of the collector circuit inductance and resistance keeps Q280 conducting for about 0.6 μsec before the base drive decays. As Q280 regenerative base

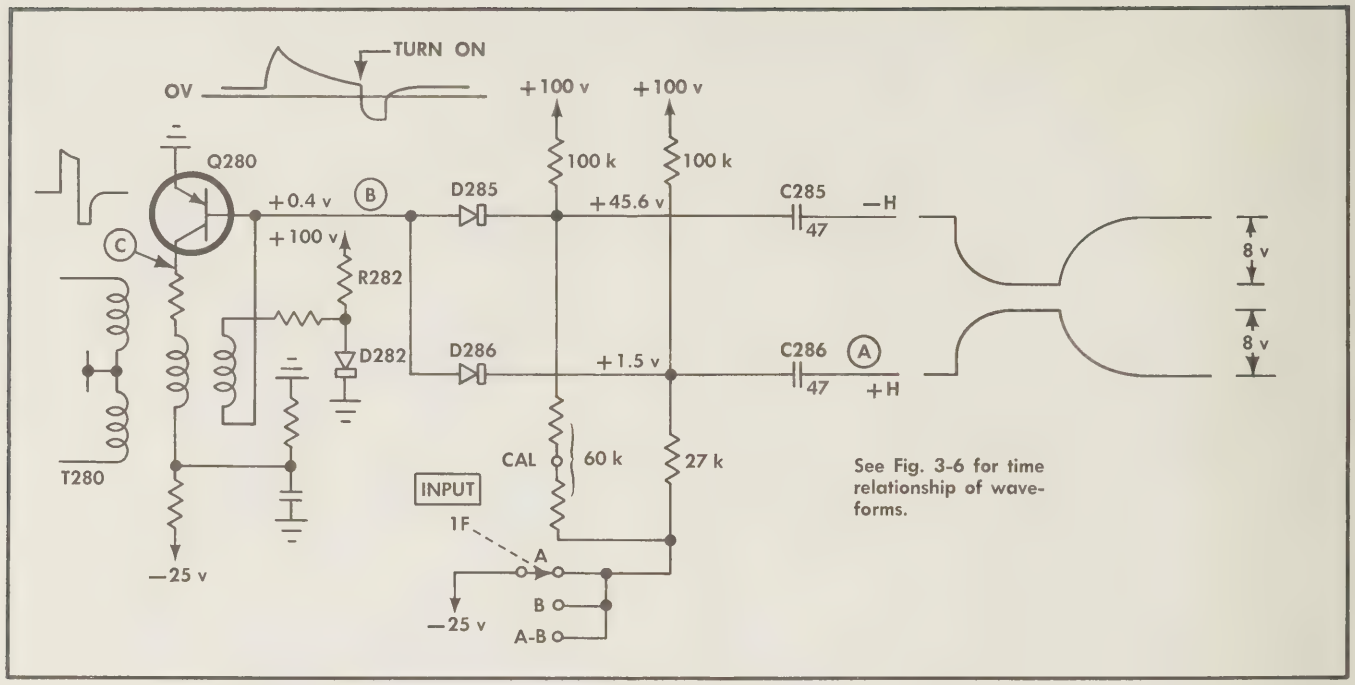


Fig. 3-7. Operation of Diode switch feeding Blocking Oscillator.

turn-on drive is stopped, the collector current drops rapidly. Dropping collector current is transformer-coupled back to the base of Q280 as a fast turn-off signal. The collector voltage waveform is shown in Fig. 3-6C. Changing collector current is also transformer-coupled to the tapped secondary that drives the sampler circuit.

Sampler Circuit. The Sampler Circuit consists of the center-tapped secondary of T280 with its dc level set by the Comparator Emitter Follower, two parallel r-c circuits and two silicon diodes. As Q280 is turned on, the secondary voltage of T280 reverse biases D292 and D293 and no current flows. As Q280 stops conducting, the secondary of T280 drives D292 and D293 into conduction and at the same time charges C292 and C293 to about 7 volts charge each. (The energy for charging the two capacitors comes from the core of T280.) D292 and D293 are computer diodes with equal forward drop at the time they conduct, making the voltage at their junction with C294 equal to the voltage at the center of T280 secondary. Thus during the "backswing" time of T280, the voltage at the center of T280 secondary appears at C294. The backswing lasts for about 0.4 μsec, plenty of time to fully charge C294 to the voltage of the Comparator Emitter Follower. During each backswing, C292 and C293 are recharged to replace the small amount of voltage discharged by the resistors R292 and R293. The time constant of the two r-c circuits is 1 msec each, many times longer than the 63.5 μsec between sampling times.

Memory Circuit. The Memory Circuit is the Memory Capacitor C294 and the grid of V293A. Since D292-D293 are silicon diodes with very high reverse leakage, the memory capacitor charge is essentially constant between samples.

The four waveforms of Fig. 3-6 (taken with a four-channel oscilloscope) show the time-coincidence of the Dc Restorer circuit. Note that some of the color burst is "seen" by the sampler and memory capacitor. The reactance of the memory capacitor is about 440 ohms at 3.58 mc; and the sampling diodes are turned on hard by T280 secondary so there is no color burst rectification. Thus the Dc Restorer acts upon the average voltage of the color burst, keeping the display at the same stable position with or without the color burst.

Restorer Cathode Follower. The Restorer Cathode follower is an impedance transformer that couples the sampled and stored voltage into the Vertical Amplifier minus input grid. The two resistors, R298 and R299 offset the dc level of V293A cathode to the correct value for the minus input, setting the minus grid to essentially ground voltage when the system is correctly balanced.

Restorer Operation On Calibrator signal. This mode of Restorer operation uses the —H regenerated horizontal sync pulse to fire the Blocking Oscillator. The —H signal starts negative at the same time the Calibrator signal goes negative. The Blocking Oscillator fires as the —H signal goes negative, causing the Dc Restorer to sample the signal voltage about 0.88 μsec after the beginning of the Calibrator negative half-cycle. Thus the display is stabilized at the bottom of the Calibrator signal and held in the same position as the back porch was held.

Video Out Amplifier. The Video Out Amplifier receives its signal from the emitter of Q114. The input impedance of Q174 is greater than 50 K due to the large amount of emitter degeneration, loading Q114 lightly. Q174 produces an inverted current drive to the feedback amplifier Q184-Q193 of essentially 1 ma per 1 volt. The emitter impedance of Q174 is R172-R173 in parallel, or 1.06 K. Since the collector current of Q174 changes linearly with base voltage drive, the signal source resistance of Q184 base is 1.06 K. Then the voltage gain of Q184-Q193 (set

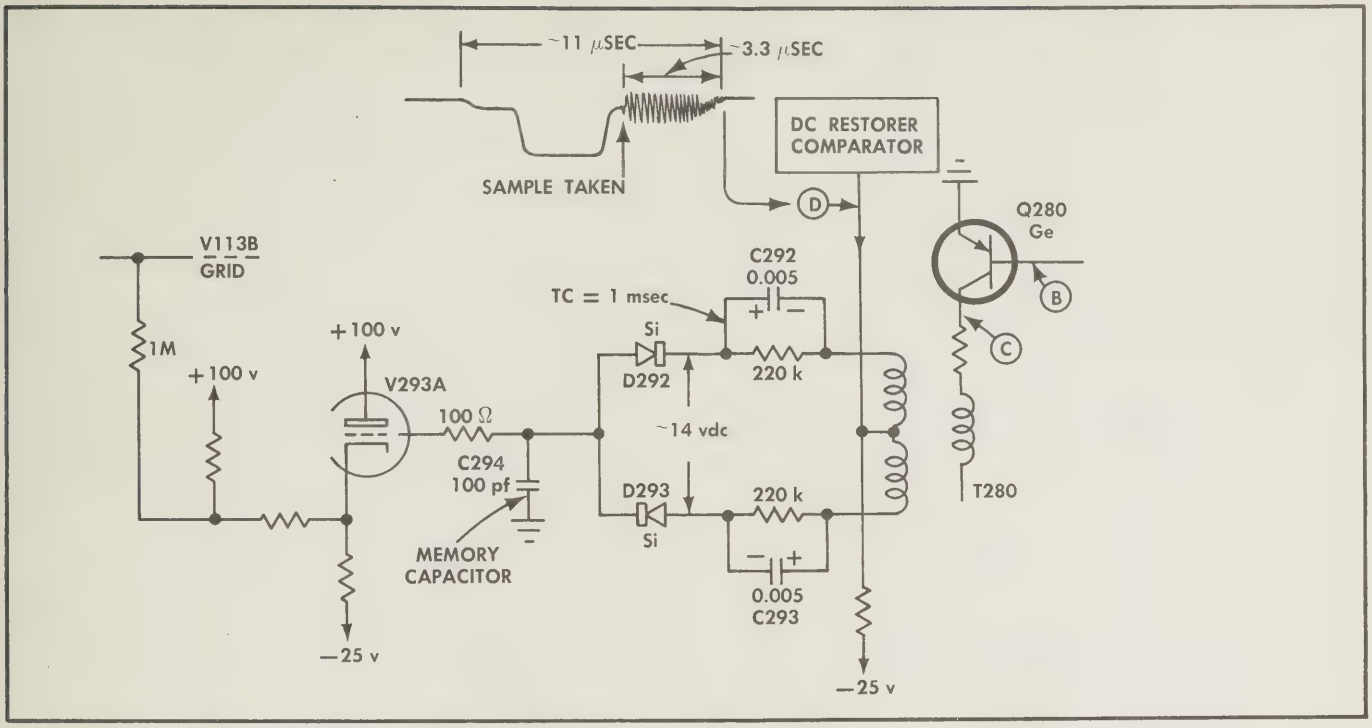


Fig. 3-8. Sampling and memory portions of Dc Restorer circuit.

by the feedback resistance divided by the input resistance) is 2.2 K/1.06 K or 2.06. Assuming 3% signal loss in the Preamplifier, the gain from input to Q193 collector is 2. R198 in series with a 75-ohm load makes the overall gain 1. The feedback (R192) makes the Video Out amplifier have a very low output impedance. Thus the amplifier is matched to the output coax line by inserting a series 75 ohm resistor (R198). The reactance of C198 is so low at the frequencies passed by the circuit that it does not increase the output resistance over that of R198. R199 assures that C198 is properly charged.

The Video Out Amplifier also serves as internal trigger amplifier. The output lead to the Trigger Generator Trigger Amplifier rests at —5 volts.

The Sweep Generator applies a positive pulse to the Video Out jack when operating in a delayed mode. The intensifying pulse amplitude is about 0.2 volt at the Video Out jack (0.1 volt when loaded with 75 ohms). The value of the pulse is set by current from a +100-volt pulse in the Sweep Generator unblanking circuit applied through 39 K (R476 diagrammed near Unblanking Amplifier with the Sweep Generator) to the 75 ohm output resistor R198. The very low output impedance of the Video Out Amplifier prevents the intensifying pulse from disturbing the internal triggering signal.

TRIGGER GENERATOR

The Trigger Generator processes composite video so the Sweep Generator is triggered properly for the various modes of the DISPLAY switch.

The input to the Trigger Amplifier can be from one of two sources; the internal trigger signal from the Video Out Amplifier or an external sync input, usually composite video. The selection of source is made by the Sync switch. Source switching is by diodes, and the actual SYNC switch is isolated from the video leads by R305. When the SYNC switch is set to INT, D301 is back biased and D304 is forward biased. The signal passes through forward biased D304 into the grid of V293B. When the SYNC switch is set to EXT, D304 is back biased and D301 is forward biased, so the signal passes through D301. The internal-external sync selection can be made from the front panel for all vertical input modes except when viewing the Calibrator signal. When the vertical INPUT switch is at CAL, the sync input is automatically switched over to internal.

Trigger Amplifier

The Trigger Amplifier has two feedback loops. One is a normal type made up of R315, with the gain of Q314 set by R315 and the transconductance of V293B.

A feedback amplifier of the type in the Trigger Amplifier, and diagrammed in Fig. 3-9, has low input impedance called virtual ground, and a low output impedance. The virtual ground is easy to visualize when we find equal and opposite currents in the input resistor (Ri) and the feedback resistor (Rf). Assume Rf of Fig. 3-9 to be 22 k and Ri to also be 22 k. A one volt IN signal will cause 0.045 ma to flow in Ri. The transistor collector will change voltage level (also 1 volt) until an opposite 0.045 ma flows in Rf at which time the input signal is balanced so none is left for the base. When Ri = Rf the voltage gain is unity.

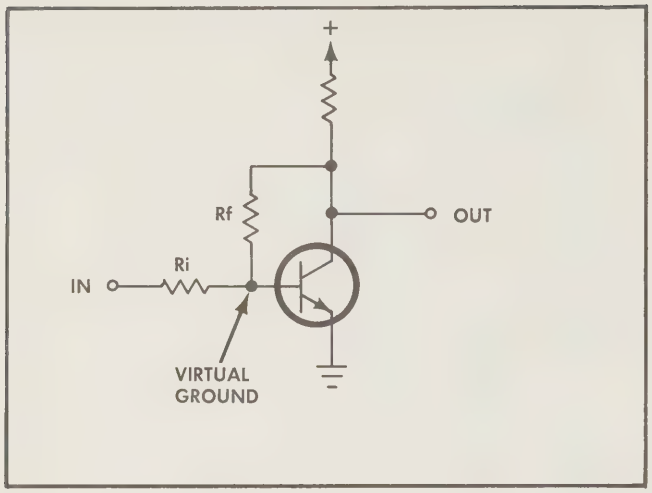


Fig. 3-9. Simplified feedback amplifier.

V293B cathode output impedance is approximately equal to 1/Gm or typically 1/0.001 mho = 1000 Ω. (Normal range of output resistance between tubes will be from about 600 to 1200 Ω.) The cathode follower output resistance can be considered directly in series with the input grid for calculating signal current to the base of Q314. Thus the typical voltage gain of Q314 is $\frac{22\text{ k}}{1\text{ k}} = 22$.

A second feedback loop around the Trigger Amplifier acts as a dc restorer for signals into the rest of the Trigger Generator. Negative-going composite video at the grid of V293B causes the collector of Q314 to go positive. D317 will conduct when the collector of Q314 becomes more positive than the grid of V293B by about half a volt (D317 is a silicon diode). Conduction of D317 tightly couples the grid of V293B to the collector of Q314, causing the Trigger Amplifier gain to be less than unity. As D317 conducts on sync tips, C304 charges a bit positive. As the collector voltage of Q314 falls and D317 stops conducting, C317 gains a negative charge that is the average of the input signal amplitude. C304 thus receives a charge via D317 on sync tips and discharges through R318 to C317 at all other times. The discharge current for C304 is approximately proportional to video level. The effect of the action just described is that C304 acts as a dc restorer for the Trigger Amplifier for a wide range of signal levels. Restorer action thus holds the Trigger Amplifier output (at the sync pulse tips) at a stable level of about —0.5 volt.

Video stripping occurs in the Trigger Amplifier as the input signal goes positive because available Q314 collector current through R314 is all taken by the feedback resistor R315. As V293B cathode applies positive-signal turn-on current to the base of Q314, Q314 collector goes negative until the current in R315 equals the current in from V293B cathode. At that point the collector voltage stops going negative and the remaining positive signal input to V293B grid is not amplified. Thus the dc restored sync tips out of the Trigger Amplifier have a maximum peak amplitude of about 13 volts with the video information removed from large signals.

Trigger Shaper

The Trigger Shaper is a Schmitt multivibrator whose operation is bistable due to the dc coupled input signal from Q314 collector. Q335 conducts when the base of Q325 is near ground, and Q325 conducts when the input is more negative than about —4 volts. Output signals are each about 8 or 9 volts peak-to-peak. The TRIG MULTI BIAS control is adjusted for proper triggering on low level video sync signals in case the Trigger Amplifier input signal is less than normal.

Assume Q325 is conducting. As the input signal goes positive, current in Q325 is reduced, allowing its emitter to go positive and its collector to go negative. Q325 emitter is coupled to Q335 emitter and Q325 collector is coupled to Q335 base. Initially the back-bias at the base-emitter junction of Q335 prevented its conduction. As Q335 bias reaches the point of conduction, regenerative action flips the conduction from Q325 to Q335 rapidly. As long as a sync tip holds the base of Q325 up near ground, Q335 will conduct. As Q325 base starts negative, Q325 begins to conduct and a second regenerative action switches Q335 off and Q325 on. The regenerative path is between the emitters of Q325-Q335 and from the collector of Q325 to the base of Q335.

Both the +H and —H signals are available for the Keyed Dc Restorer previously described, and for the rest of the Trigger Generator.

Field Selector

The Field Selector circuit includes the Vertical Sync Separator, the Even Field Recognition circuit and the Field Trigger Generator.

Vertical Sync Separator. The Vertical Sync Separator is primarily a differentiator and an amplifier biased off about 3 volts. The differentiator, C341-R341 shifts the signal output dc level depending on the pulse duty cycle. If the incoming square-wave signal negative peaks are of longer duration than are the positive peaks, the output will be more positive than negative. Likewise if the incoming signal positive peaks are of longer duration than are the negative peaks (vertical sync), the output will be more negative than positive. During the time C341 receives only regenerated horizontal sync pulses, the signal at the base of Q344 shifts between about 2 volts negative and 6.5 volts positive and Q344 does not conduct. As the vertical sync group occurs, the signal at the base of Q344 shifts to between about 6 volts negative and 2.5 volts positive, turning Q344 on hard each time the signal goes below about —3.5 volts.

Both the Even Field Recognition circuit and the Field Trigger Generator require a single pulse, the first of the vertical sync pulses. The parallel combination of R346-D346 and the capacitance of C347 permit only the first vertical pulse through. As the collector of Q344 rises positive 20 volts, D346 passes the whole pulse to C347 (and C351). C347 charges to more than half the peak voltage of the first pulse. The very high reverse resistance of D346 and the 22 megohms of R346 let C347 keep its charge. The second vertical sync pulse is thus not able to be coupled on since the cathode of D346 is already several volts more

positive than before the first pulse. (Some of the second pulse gets through the coupling capacitors, but does not affect the following circuits.) R346 discharges C347 (and C351) before the next vertical pulses arrive.

Even Field Recognition. The Even Field Recognition circuit is a one-shot multivibrator (mono-stable) with two input paths. The single vertical sync pulse that arrives through C351 to the base of Q355 turns Q355 on and Q365 off. The switching action is regenerative due to emitter coupling, and coupling from Q355 collector to Q365 base. C360 was initially charged to about 13 volts. As Q355 collector falls, the base of Q365 is taken about 11 volts negative. The EVEN FIELD SYNC control R360, in series with R361 starts the base of Q365 back toward ground, discharging C360. As the voltage at the base of Q365 nears a value that would cause Q365 to turn on, a positive pulse coupled to the base through C361 will turn it on and reset the multi. The time constant of C360 and R360-R361 is set such that the multi is reverted at the end of the last vertical equalizer pulse. (The waveforms at the collector of Q365 on the diagram at the back of this manual show capacitively coupled pulses that pass through C461 and the base-to-collector capacitance of Q365. This is normal and does not indicate Q365 to be defective.) As Q365 collector goes negative at the end of the last equalizing pulse C364 and R368 form a negative pulse that "ramps up" for a period of 50 to 55 μsec. C370 couples differentiated —H pulses and adds them to the ramp at the junction of R369 and D370. If a horizontal pulse occurs during the time the ramp is running up, the output through D370 is more negative than at any other time. An odd field interlace horizontal sync pulse occurs in the middle of every other ramp.

All the other negative pulses at the junction of R369-D370 charge C371 (through R372) to an essentially stable dc voltage (R371 does not appreciably discharge C371 between pulses). As an odd field occurs, the more negative pulse that coincides with the even field recognition ramp is coupled through D371 to the base of Q374, flipping the Field Trigger Generator so Q375 conducts.

Field Trigger Generator. The Field Trigger Generator is a bistable multivibrator that changes state each time a positive pulse arrives through C347 from the Vertical Sync Separator. The triggering pulse is coupled to the bases of Q375-Q385 through diodes D374-D384 and the r-c networks of C375-C385. The positive polarity pulse turns off the conducting transistor regardless which one is conducting. The pulses arrive at a 60 cps rate causing the Field Trigger Generator to have a 30 cps output rate at each collector.

If Q375 is off when the negative-going even field signal from the Even Field Recognition circuit arrives at the base of Q375, then Q375 will be turned on. A positive signal from the sync separator to each collector at the start of each field, and a negative pulse to Q375 base at each even field assurse that the Field Trigger Generator output is always related to the odd and even fields of the composite video. The collector of Q375 always goes positive (toward ground) at the beginning of each even field. The collector of Q385 always goes positive at the beginning of each odd field.

Field shift switching is the selection of the correct Field Trigger Generator output pulse by a dual-input single-output diode switch. Positive going trigger pulses are needed by the Sweep Generator and by the Delay Generator. Thus, to trigger on an even field, the Field Shift switch causes Q385 collector signal to be coupled on, and for an odd field Q375 collector signal to be coupled on.

Assume an odd field trigger is selected. The crt display will start the sweep on an even field and show the odd field at center screen. The FIELD SHIFT switch (set at EVEN) applies a negative bias to D377 anode, assuring that it cannot conduct the signal from Q375 collector to the following circuits. D387 will pass the positive portion of the differentiated Q385 collector signal. Differentiation of Q385 collector signal is by C384 and the parallel resistance of R388 and R379-R389. As Q385 collector rises, C394 couples the first of the full step through to D389 and the rest of the circuit. C384 soon charges, dropping the voltage at the cathode of D387 back to ground level. As Q385 collector falls, D387 disconnects the signal from the rest of the circuit and R388 recharges C384 for the next positive pulse. The contacts of K385 are described with the Staircase Amplifier later in this section.

Delay Generator. The Delay Generator consists of a transistorized sawtooth generator and a triggered Blocking Oscillator. Delayed line-trigger pulses occur once each field, an adjustable amount of time after each vertical sync pulse.

Sawtooth Generator. The Sawtooth generator is normally biased so Q405 is conducting and Q415 is cut off. Q415 collector rests at +24 volts because of the voltage divider R414, R415-D415. (The DELAY control current from —25 volts through R428 to the junction of R415-D415 will not take the junction significantly below ground because there is 24 volts across R415 and there can be up to 25 volts across R428.) Q405 collector rests at —0.65 volt. holding Q415 base at about —6 volts by R405-R406. Q414 is saturated (collector voltage pulled down very near emitter voltage) due to base current through R417. Thus the current in Q405 emitter is set by R419 and the —24 volts at Q414 collector, and the current in Q405 collector is set by R404. The sweep generator will remain in this condition until a positive trigger pulse arrives at the base of Q415.

As a positive pulse turns on Q415, the current through Q414-R419 shifts to Q415 and Q405 turns off. As Q415 collector starts negative, C417 couples the voltage change into the base of Q419 in a direction to reduce its collector current. As the base of Q414 is taken far enough negative to almost turn off its collector current, the drop in Q415 collector voltage is nearly stopped until the current through R417 discharges C417. As C417 discharges a bit, the base voltage of Q414 turns on current a bit more. The current of Q414 is also the current in Q415 which again pulls down on C417. The result of the feedback just described is that C417 is discharged very linearly by current through R417. The voltage at the junction of C417-R417 remains essentially constant while the collector of Q415 pulls the other side of C417 negative at a rate set by the current of R417.

When the collector voltage of Q415 reaches ground level and stops going negative, current through R417 raises the base voltage of Q414 and increases its current. Increased current in Q414 pulls both Q415 emitter and base elements negative, allowing the collector to go negative

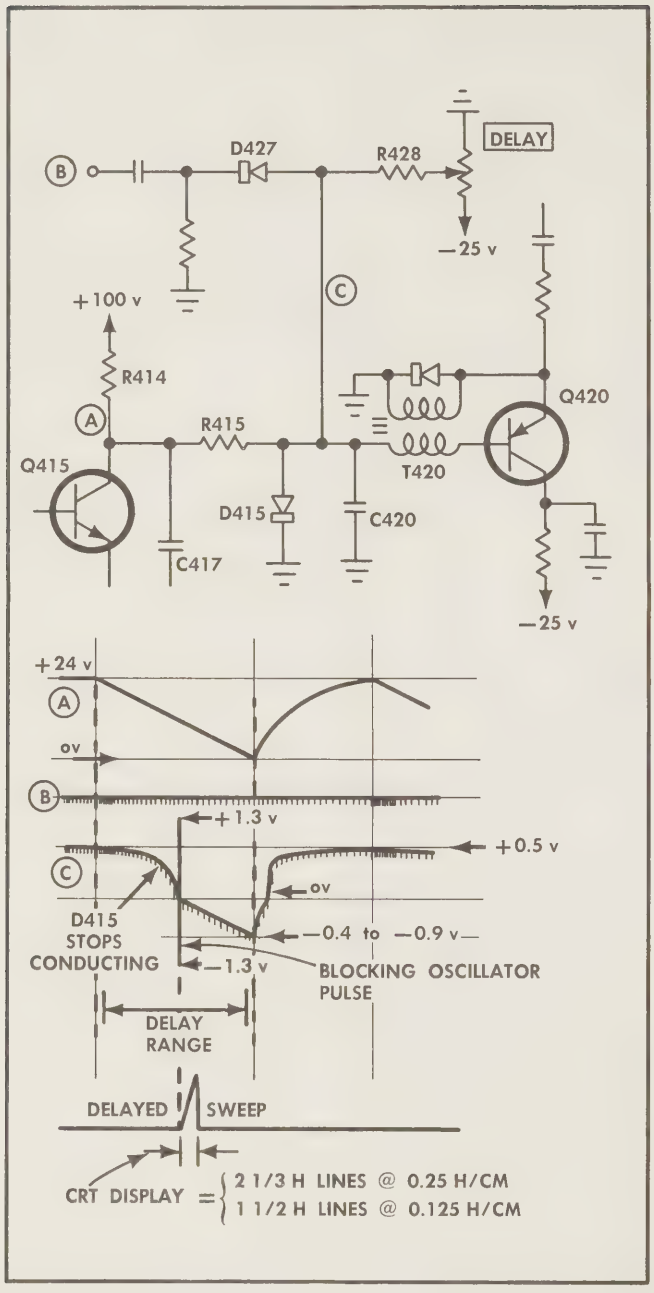


Fig. 3-10. Blocking Oscillator circuit and waveforms.

too. The common emitter-to-emitter lead of Q405-Q415 drops negative until Q405 again turns on. The collector voltage of Q405 drops and quickly turns Q415 off, letting its collector voltage rise in the positive direction as R414 charges C417 to its original state. (C414 cancels Q415 initial negative collector surge caused by shifting Q414 current from about 5 ma in Q405 to about 0.27 ma in Q415. Without C414, the collector voltage of Q415 would drop sharply negative at the time Q415 was triggered into conduction.) C417 charging current is limited only by R414 since the capacitator negative end is tied to −25 volts through Q414 base-emitter junction.

Blocking Oscillator. The Blocking Oscillator and its signals are shown in Fig. 3-10. The knee of waveform C where D415 stops conducting is adjustable by the DELAY control. The knee is the point at which R415-R428 voltage division of the sawtooth causes the voltage at the blocking oscillator input to start negative. Negative differentiated horizontal sync pulses (waveform B, with their positive peaks removed by D427) are added to the sawtooth so that the blocking oscillator will fire at the time of a horizontal sync pulse. As the base of Q420 is pulsed far enough negative to cause it to conduct, transformer regenerative feedback turns it on hard. The collector is held stable for a short period of time by C424, causing the emitter to go sharply negative until it is more negative than the base. This turns off the drive and T420 aids in quickly turning off the pulse. R420 helps dissipate base winding inductive energy, and D420 helps dissipate emitter winding energy so a second ringing type pulse is not generated. The negative emitter pulse is coupled to the trigger selector switch through R436-C436.

Line Trigger Selection

Selection of recurrent negative line trigger pulses at the beginning of each horizontal line, or delayed field pulses, is made in a diode switching network of the DISPLAY switch.

When the DISPLAY switch is at either of its DELAYED LINE positions, the cathode of D430 is raised about 9.5 volts positive and the diode is reverse biased so it cannot conduct negative line-triggers to the Sweep Generator. D436 does conduct negative delayed-field pulses to the Sweep Generator.

When the DISPLAY switch is at 2 LINE, .25 H/CM, or .125 H/CM, D436 cathode is reverse biased about +29 volts to prevent delayed-line pulses from getting to the Sweep Generator. D430 does conduct negative line-trigger pulses to the Sweep Generator.

When the DISPLAY switch is at 2 FIELD, both D430 and D436 are reverse biased so no negative triggers get to the Sweep Generator. At the same time the Sweep Generator input circuit (diagrammed with, and described with the Sweep Generator) is biased by another section of the DISPLAY switch to conduct positive field-triggers to the Sweep Generator.

SWEEP GENERATOR AND HORIZONTAL AMPLIFIER

The Sweep Generator is a triggered sweep system for all positions of the DISPLAY switch except the 2 FIELD position at which it is a recurring synchronized sweep. Positive field-trigger pulses stop the sweep in 2 FIELD operation, negative line-trigger or delayed-field pulses start the sweep in all other modes of operation. The sweep rate at 2 LINE permits viewing the interlacing of the color burst. The sweep rate at 0.125 H/CM lets you look at every other horizontal line displaying a non-interlaced color burst. Refer to both the simplified Sweep Generator and Horizontal Amplifier diagram of Fig. 3-11 and the complete diagram at the back of this manual during the following circuit description.

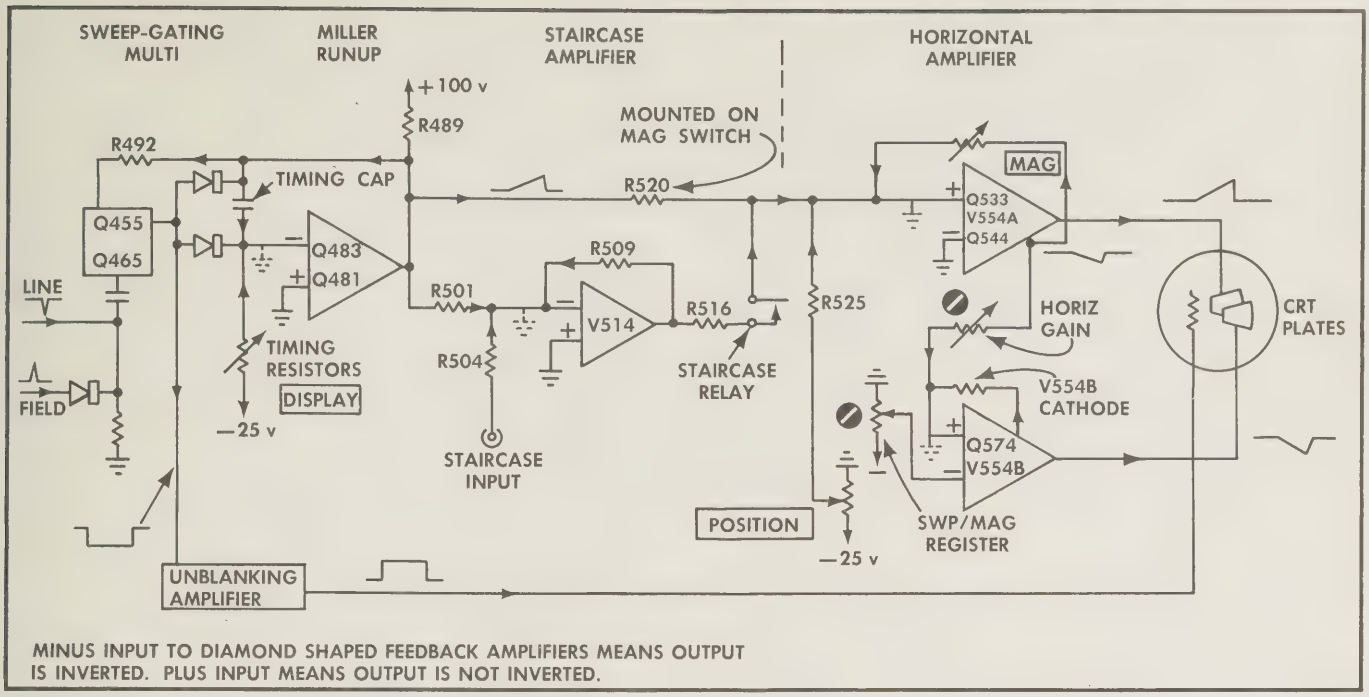


Fig. 3-11. Simplified Sweep Generator and Horizontal Amplifier.

Sweep Gating Multi

The Sweep Generator is operated in two basically different modes of operation as suggested in the previous paragraph. The Sweep Gating Multivibrator operation is altered from a triggered system for line displays to a free-running stopped-sweep system for 2 field displays.

2 LINE DISPLAY. (Vertical INPUT Switch at A, DISPLAY Switch at 2 LINE). The Sweep Generator is held in one state by the Sweep Gating Multivibrator until the arrival of a negative trigger pulse. Before receipt of a trigger pulse, the following conditions exist:

a. Q455 is conducting, Q465 is in a state of non-conduction.

b. Both Disconnect Diodes are conducting. D482 is applying positive turn-on current from R468 to the Miller Runup input base, while D481 is limiting the turn-on current, as the collector of Q481 pulls down and takes some of the current flow from R468.

c. Q481 collector voltage is at about +1 volt, so that essentially no current is delivered through R520 to the Horizontal Amplifier.

d. The Unblanking Amplifier output is near ground, turning off the crt beam.

e. The crt horizontal deflection plates hold the blanked beam at the left side of the crt (depending upon the setting of the POSITION control).

Q455 is held in conduction by current through the series resistors R464-R465 and D466, limited by R470 current into the base-emitter junction of Q474. The base turn-on current to Q455 is enough to saturate it, but D455 bypasses some of the intended base current when the collector voltage drops slightly below D466 anode voltage and pervents the transistor from saturating. (If Q455 were to saturate, the base-emitter junction would hold so many carriers that the transistor could not be turned off quickly.) Q455 collector voltage near ground assures that no current reaches the base of Q465, and Q465 remains cut off.

As the negative-going line trigger pulse arrives at the base of Q455 through C452, Q455 is turned off. The voltage rise at the collector of Q455 is coupled to the base of Q465, turning it on. As current begins to flow in Q465, its collector voltage drop aids in turning Q455 off and the switching action takes place very rapidly. (Consider the emitter of Q465 as grounded: the three components in its emitter circuit are used in 2 FIELD operation and are of no importance in 2 LINE operation.)

Miller Runup

As Q465 collector voltage falls below about +1.3 volts, D464 conducts and takes the anodes of the Disconnect Diodes toward ground. Both D481 and D482 stop conducting. The timing resistor current that had been flowing through D482 is immediately transferred to the base of Q483. The current that had been flowing in D481 through Q481 is canceled by a slight drop in voltage at the base of Q481. As Q483 base starts negative, the base of Q481 also starts negative and reduces its collector current, causing its collector voltage to start positive. The timing capacitor couples the positive voltage of Q481 collector back to Q483 base, essentially stopping its negative travel. The result is that the timing capacitor receives a charge at a rate set by the timing resistor, creating a very linear positive-going sawtooth voltage at the collector of Q481. The Miller Runup circuit can be defined as a feedback amplifier, with the feedback element a timing capacitor, and the input resistor

a timing resistor; the input signal is the —25-volt supply (see Fig. 3-9 and associated text for description of a feedback amplifier).

The sweep voltage rises positive until R492 raises the base voltage of Q455 far enough to revert the Sweep Gating Multi. As Q455 conducts, the collector voltage of Q465 rises in the positive direction. D464 stops conducting and R468 raises the base voltage of Q483 positive through D482. This causes collector current in Q481 to increase rapidly. This collector current discharges the timing capacitor at a linear rate set by R468. As Q481 collector voltage approaches the voltage at the base of Q483, D481 takes some of the R468 current and stops the rundown. (D486 offsets the base voltage of Q481 in a direction to limit the quiescent current in D481, permitting the next sweep runup to start linearly.) The rate of rundown is slow enough that the sweep is triggered every other horizontal sync pulse, presenting a non-interlaced color burst. The Sweep Generator then waits for another negative line-trigger pulse to turn Q455 off and start the cycle over again.

2 FIELD DISPLAY. Operation of the Sweep Gating Multivibrator is changed from requiring a trigger to start the sweep, to automatically starting the sweep and using a trigger to stop it. If the sweep is not running when the DISPLAY switch is set to 2 FIELD, Q465 of the Sweep Gating Multi is not conducting. The DISPLAY switch connects R461 to the —25-volt supply and the emitter voltage starts negative. D461 is reverse biased, and the rate of fall is set by the time constant of R461-C461. Approximately 1 millisecond after Q465 emitter voltage starts negative, the Sweep Gating Multi switches so that Q465 is on and Q455 off. The sweep voltage runs up as described for 2 LINE operation.

The DISPLAY switch also changes the output of the Trigger Generator and forward biases D452 through R450 so that positive pulses will come through D452, and turn Q455 on to stop the sweep. The positive pulse that turns Q455 on occurs at every other vertical sync pulse. The sweep is stopped, runs down very rapidly due to additional rundown current from R453 in parallel with R468, waits 1 millisecond and automatically starts again, just before the video portion of the next field.

In the event Vertical input composite video stops, the sweep will continue to cycle, but instead of positive pulses stopping the sweep, Q455 is turned on by sweep voltage feedback through R491-R492 in the same manner as described for 2 line operation. Thus, the RM529 Monitor will show a sweep without vertical information when the DISPLAY switch is set to 2 FIELD, but requires a trigger signal for the sweep to operate in all other positions of the DISPLAY switch.

With the DISPLAY switch set to CAL, R469 is placed in parallel with R468 so the rundown rate will be rapid enough to prepare the sweep to run again at the next calibrator signal transition. This assures a cleanly triggered Calibrator display without the possible jitter caused by a longer rundown.

The runup rate of the Miller Runup circuit is slowed by adding C483 across the timing capacitor used in 2 LINE operation. C483 does not affect the sweep voltage peak value, but changes only the rate at which the spot moves across the crt. Television systems with different time per field than the U.S. rate of 30 cps require changing the value of C483 to change the sweep rate. For longer time per field, increase C483 value; for less time per field, decrease C483 value. Modification of C483 is normally made at the factory at time of purchase.

The Miller Runup circuit drives both the Horizontal Amplifier and the Staircase Amplifier.

Horizontal Amplifier

The Horizontal Amplifier is a combination of feedback and paraphase amplifier. The base of Q533 is the "virtual ground" summing input terminal to the whole amplifier. Voltage gain of the overall amplifier is the ratio of the MAG resistance to the input resistance of R520. The dc level of the output (positioning) is through R525 to the base of Q533. The input to a feedback amplifier can have several input resistors and signals. The gain of each is the ratio of feedback resistor to input resistor. Feedback is from V554A cathode to the base of Q533. V554A cathode is also the signal source for the inverting half of the amplifier, through the HORIZ GAIN control R558-R568 to the base of Q574. Feedback in the inverting half of the amplifier is the cathode resistance of V554B to the base of Q574. Fig. 3-11 shows the POSITION and SWP/MAG REGIS controls separately. They are actually in series, but only for current conservation since there is no signal coupling or interaction between them. The SWP/MAG REGIS control sets the dc balance of cathode voltages of V554A-V554B so the display center does not shift as the MAG switch is changed.

The sweep sawtooth enters through R520. Q533 is an emitter follower and current gain transistor driving the inverting amplifier Q544. Q544 signal output receives current gain in the cathode of V554A assuring linear feedback from a low impedance. The plate of V554A provides a +150 volt swing that would be impossible to achieve with transistors. It acts in a normal vacuum tube fashion, with the input grid signal appearing inverted at the plate output.

The HORIZ GAIN resistance is degenerative to V554A and is the signal coupling path to Q574. The signal from V554A cathode to Q574 base runs negative, inceasing the current in Q574 collector. The collector voltage of Q574 becomes less negative and drives the grid of V554B to increase V554B current, raising the cathode to the level it had before the signal started negative. Note that the base of Q574 acts as a virtual ground for signals. V554B grid swings about 6.6 volts, turning on plate current so the plate swings about —150 volts.

Staircase Amplifier

V514 is a feedback amplifier with two input resistors to sum the sawtooth and studio color camera staircase voltages. When the control lead, pin D of J501, is externally grounded, K385 causes R516 to become the third input to the horizontal amplifier. V514 inverts the sawtooth voltage so that the summed sawtooth signal to Q533 base is one-third its normal amplitude. The external input negative staircase signal is inverted by V514.

With the staircase most positive, the sweep runs for the period of one field, and is reverted by a vertical sync trigger. At the time the sweep is reverted, the staircase drops negative to its second level. The sweep starts again, but begins one third of the way across the crt due to the staircase

positioning signal. Again the sweep runs for one field, is reverted and the staircase drops to its third level. Once again the sweep starts, but two-thirds of the way across the crt. Thus, the three color camera signals can all be viewed in one crt display.

The staircase level shift takes about 800 μsec. With the Sweep Gating Multi operating in 2 FIELD the sweep restarts in about 1 msec, so the change in staircase is not seen because the crt beam is blanked off at the same time.

Closing the staircase relay also changes the timing resistor so the sweep rate is twice as fast as that for 2 FIELD operation. The relay also changes the operation of the Field Trigger Generator to put out a positive pulse at each vertical sync pulse time instead of at every other one. Thus the sweep recurs at a 60 cycle rate, taking three sweeps to get across the crt.

Unblanking Amplifier

The Unblanking Amplifier Q474 responds to the Sweep Gating Multi Q465 collector signal. When there is no sweep, the crt beam is pulled away from the deflection plates and phosphor screen, preventing any spot from being seen. Q474 collector is near ground at the time of no sweep, turning off the crt beam. As the Sweep Gating Multi switches state to start a sweep, Q474 is biased to cutoff and its collector rises to +101 volts, limited by conduction of D474 and D475.

The Unblanking Amplifier provides two more output signals during delayed sweep operation. One is the Video Out intensification discussed with the Vertical Amplifier description. The other is to increase the crt beam current to intensify the crt trace for the short duration of the delayed sweeps.

The collector signal of Q474 does not pull down on the trace intensification line; rather that line is pulled down by R476 and the —5 volts of the Video Out circuit between sweeps when the DISPLAY switch is set to either Delayed position. The collector voltage of Q474 is near ground most of the time in delayed modes, because of the short duration sweeps recurring at a 30 cps rate (once every 33.3 msec). The trace intensification line (at R477-R478 junction) drops to —5 volts in about 2.6 msec as R476-R477 discharge C478 and changes the charge on C477.

As the sweep starts, Q474 collector rises quickly, sending an integrated pulse to the crt grid circuit. R478 permits the step to rise abruptly to +22 volts, then continue to rise at an r-c rate. The rising signal to the crt grid is required because the high voltage power supply does not follow the increased current immediately, and the increasing grid signal turns on the crt at about the same rate as the supply current decreases, assuring a steady crt intensity throughout each sweep.

R476 also conducts current into the 75 ohms of the Video Out connector, adding about 0.1 volt to the video output to intensify a line of the studio monitor, identifying which line the RM529 monitor is also viewing.

LOW VOLTAGE POWER SUPPLY

The Low Voltage Power Supply provides regulated —25 volts, +100 volts, and unregulated +360 volts to the circuits of the RM529. The —25-volt supply is the reference voltage for the +100-volt supply and the Calibrator circuit.

The RM529 is powered by a dual primary power transformer for operation on either 115 or 230 volt 50-60 cps ac lines. Refer to the Operating Instruction section of this manual for converting from one supply voltage to the other.

—25-Volt Supply

Voltage for the —25-volt power supply comes from the full-wave rectifier system of D610-D611 and C610. Voltage across C610 is nominally 35 volts.

The —25-volt regulator consists of a comparator that compares a portion of —25 volts (divided by R624-R626 and the —25 VOLTS/CAL AMPL control R620) against the voltage of a precision Zener diode D614. D614 Zener voltage is about —9 volts. The comparator output at Q616 collector is inverted and amplified by Q634, which drives the series transistor Q637 in a direction to compensate for changes in the output voltage.

Assume the —25 volt load increases and the voltage goes slightly positive. Q626 turns on harder, reducing the current in Q616 so its collector goes positive. Q634 turns on harder and pulls negative on Q637 base, causing it to conduct harder, dropping the output voltage back to its proper negative level. Since the collector of Q637 is grounded, the whole supply is moved by the emitter of Q637 to make the correction. R617-C617 at the base of Q634 reduce the feedback loop high frequency gain for more stable operation with high frequency load transients. C620 and C626 aid in reducing the high frequency output impedance of the supply.

The —25-volt supply is the voltage source for the heaters of V113 and V293. R621 across V293 heater compensates the heater voltage for current taken by the Constant Current stage of the Vertical Preamplifier.

The value of the —25-volt supply directly sets the peak-to-peak amplitude of the Calibrator signal, therefore the control used to adjust the supply is labeled —25 VOLTS/CAL AMPL. See the Calibration Procedure for adjustment.

+100-Volt Supply

Voltage for the +100-volt supply is provided by the full-wave bridge rectifiers D640A-B-C-D and C640. The voltage across C640 is nominally 130 volts.

The +100 volt regulator compares a portion of the +100 volts (referenced to the —25-volt supply through the divider R641-R642) to ground at the emitter of Q644. Q643 is an emitter follower acting as an impedance transfer device to raise the base impedance of Q644 base to prevent loading the divider. Q644 amplifies and inverts any change at the base of Q643 and applies the change directly to the base of Q647. Q644 collector current is the total base current of Q647. Q647 emitter voltage follows the inverted correction signals, changing the level of the whole supply when needed.

Assume the load increases, taking the +100 volts slightly negative. Q643 drives Q644 base negative, increasing its collector current. Increased Q644 collector current is increased base current in Q647, raising the emitter positive the correct amount to restore the output voltage.

Fuse F648 protects Q647 for accidental short circuit of the +100-volt supply buss. R648 discharges C640 if the fuse is blown, but only after the ac is turned off.

C649 and C644 aid in reducing the supply high frequency impedance. R644 limits the peak current through C644 to the base of Q643 in case the supply is accidentally shorted.

R646-C646 decouple the +100-volt buss for peak current of the crt unblanking circuit.

+360-Volt Supply

Voltage for the +360-volt unregulated supply is provided by the full-wave bridge rectifiers D650A-B-C-D and C650. The voltage across C650 is nominally 255 volts, which is added to the +100-volt supply. The supply is used by the Crt High Voltage supply and the Vertical Output stage, whose current passes through the beam rotator coil.

Beam Rotator Coil. The rectangular crt is not easily rotated physically. Also, the trace changes its "level" with the graticule slightly, depending upon the monitor's relation to the earth's magnetic field. Thus, a coil is included around the crt proper allowing the operator to adjust the trace level with the graticule from the front panel.

CRT CIRCUIT AND CALIBRATOR

The Type T529 (V859) cathode-ray-tube is a rectangular, flat-faced, mono-accelerator, deflection blanked type, designed especially for the Type RM529 Waveform Monitor. Acceleration voltage is 5500 volts with —5300 at the cathode, and nominally +200 volts at the deflection plates. The phosphor is alunminized, permitting bright displays and preventing any chance of phosphor damage at any position of the INTENSITY control.

The beam is blanked between sweeps by special deflection plates (located in the focus gun area of the tube) that pull all electrons away from possibly getting to the screen. Special intensifying circuits described with the sweep generator automatically brighten delayed line displays for easy viewing of fast sweeps at low repetition rates.

High Voltage Power Supply and Calibrator

High Voltage Power Supply. The High Voltage Supply is actually a cathode modulated amplifier with positive feedback sustaining oscillation. The cathode modulation is voltage feedback from the high voltage output that controls the level of oscillation. The Calibrator transistor Q874 is directly in the feedback path that sustains oscillation.

As the monitor is turned on, V800B is turned off due to its cold heater. The voltage divider of R875-R876 turns on Q874 so its collector voltage is about —10 volts. Q874 collector is directly connected to the grid of V800B. V800B will conduct with its grid at —10 volts. As V800B warms up and pulls plate current, Q874 collector receives a transformer-coupled turn-off signal and its collector voltage turns on V800B even harder. The secondary of T801 is a tank circuit, resonant at about 30 kc. Thus, Q874 first receives a turn-off pulse, and then as T801 secondary swings through a cycle, Q874 is turned on hard, turning V800B completely off. The cycle of oscillation repeats, heating the cathodes of V822 and V832. As they conduct, high voltage is developed that soon reduces current in V800A and Q804 to limit the current of V800B. Any further changes in output high voltage will change the conduction level of V800B to correct and restore the supply voltage.

V822 and V832 are the diodes of a half-wave voltage doubler with C837 and C848 the main filter capacitors. C837 also couples fast output voltage changes to the control tube V800A.

The multiple-resistor bleeder of R834 through R847 also provides voltage division for the INTENSITY and FOCUS controls. C849 assures there is no voltage ripple between the cathode and grid of the crt which would otherwise intensity modulate the trace.

Neon bulbs placed across the ASTIG control assure that the astigmatism element voltage remains constant to the average voltage of the Vertical Deflection plates which also use the unregulated +360-volt supply.

Calibrator. The calibrator voltage is a secondary benefit of the high voltage oscillator. Q874 collector voltage swings between essentially ground and the —25-volt supply, providing a stable square wave. D881 sets the ground level, and the —25-volt supply sets the negative level. R881, R885 and R886 divide the 25 volt swing for use in the Vertical Input when the vertical MAG control is at X1. As the gain of the Vertical Amplifier is increased with the vertical MAG switch, R882 and/or R883 reduce the calibrator output amplitude to keep the display on the crt screen.

External Calibrator signals see a 1 megohm load when the CALIBRATOR switch is set to EXT.

SECTION 4

MAINTENANCE

Visual Inspection

If trouble occurs in the Type RM529, make sure the associated equipment is operating and the controls are properly set. If it is determined that the trouble is definitely in the Type RM529, a visual check may reveal the cause. Defects such as loose or broken connections, frayed or broken cables, damaged connectors, burned components, and broken switches can generally be detected by a visual inspection. Except for heat-damaged components the remedy for such defects is obvious. Overheating of components is usually a symptom of other, less apparent troubles in the circuit. For this reason, it is essential to determine the actual cause of overheating before the damaged parts are replaced; otherwise, the damage may be repeated.

Parts Removal and Replacement

Whenever a part is replaced, check and adjust the instrument calibration as necessary. Most parts in the Type RM-529 can be replaced without detailed instructions. Some, however, are best removed and replaced by using definite procedures contained in the following paragraphs. (Parts ordering information is included in the Parts List section of this manual.)

CAUTION

Turn ac power off before removing tubes or transistors from their sockets.

Transistor Replacement. Transistors should not be replaced unless they are actually defective. Transistor defects usually take the form of the transistor opening, shorting, or developing excessive leakage. To check a transistor for these and other defects, use a transistor curve display instrument such as a Tektronix Type 575. However, if a good transistor checker is not readily available, a defective transistor can be found by signal-tracing, by making in-circuit voltage checks, by measuring the transistor forward-to-back resistance using proper ohmmeter resistances, or by using the substitution method. The location of all transistors is silk-screened on the chassis next to each socket.

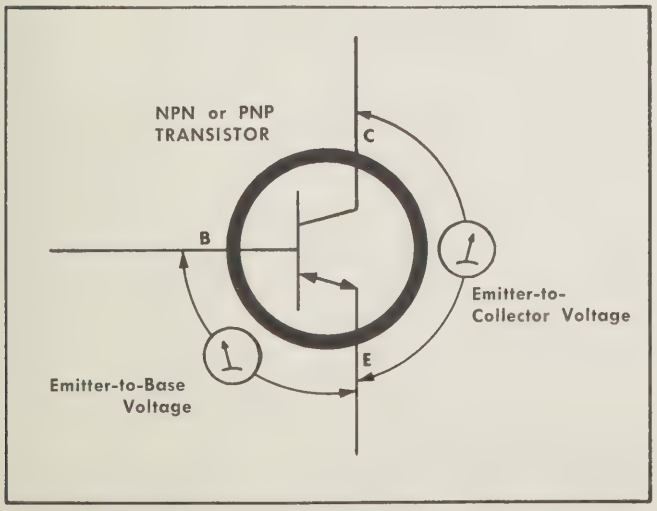


Fig. 4-1. In-circuit voltage checks NPN or PNP transistors.

To check transistors using a voltmeter, measure the emitter-to-base and emitter-to-collector voltages and determine if the voltages are consistent with the normal resistances and currents in the circuit. See Fig. 4-1.

To check a transistor using an ohmmeter, know your ohmmeter ranges, the currents they deliver, and the internal battery voltage(s). If your ohmmeter does not have sufficient resistance in series with its internal voltage source, excessive current will flow through the transistor under test. Excessive current and/or high internal source voltage may permanently damage the transistor.

NOTE

As a general rule, use the R X 1 k range where the current is usually limited to less than 2 ma and the internal voltage is usually 1 ½ volts. You can quickly check the current and voltage by inserting a multimeter between the ohmmeter leads and measuring the current and voltage for the range you intend to use.

When you know which ohmmeter ranges will not harm the transistor, then use those ranges to measure the resistance with the ohmmeter connected both ways as given in Table 4-1.

TABLE 4-1

Transistor Resistance Checks

Ohmmeter Connections*	Resistance Readings That Can Be Expected Using the RX1 k Range
Emitter-Collector	High readings both ways (about 60 k to around 500 k).
Emitter-Base	High reading one way (about 200 k or more). Low reading the other way (about 400 Ω to 2.5 k).
Base-Collector	High reading one way (about 500 k or more). Low reading the other way (about 400 Ω to 2.5 k).

***Test prods from the ohmmeter are first connected one way to the transistor leads and then the test prods are reversed (connected the other way). Thus, the effects of the polarity reversal of the voltage applied from the ohmmeter to the transistor can be observed.**

If there is doubt about whether the transistor is good or not, substitute a new transistor, but first be certain the circuit voltages applied to the transistor are correct before making the substitution.

When checking transistors by substitution, be sure that the voltages and loads on the transistor are normal before

making the substitution. If a transistor is substituted without first checking out the circuit, the new transistor may immediately be damaged by some defect in the circuit.

Replacement of either Q637 or Q647 requires removal of only the transistor mounting bolts. The mounting bolts are held by permanently mounted nuts in the rear heat-sink. No washers are used.

Remove the mounting bolts and pull the transistor and its leads a short distance away from the heat-sink. Note the wire color-code for correct resoldering to the leads of the new transistor. Unsolder the defective transistor. Wipe a small amount of non-melting silicone grease such as Dow Corning 4 Compound on the under-side of the new transistor.

WARNING

Silicone grease will irritate and may damage eye tissues if admitted to the eye. Wash your hands thoroughly after this procedure BEFORE touching the face.

Solder the leads to the new transistor using long nose pliers on the transistor lead as a heat-sink. Push the transistor into place making certain the leads are separated, and reinstall the mounting bolts. Wipe excess silicone grease away from the transistor edge with a disposable tissue.

Tube Replacement. Tester checks on tubes used in the Type RM529 are not recommended. Tube testers sometimes indicate a tube to be defective when that tube is operating satisfactorily in a circuit, or they may fail to indicate tube defects which affect the performance of the circuits. The criterion for the useability of a tube is whether or not it works properly in the circuit. If it does not, it should be replaced. Unnecessary replacement is not only expensive but may also require needless recalibration of the instrument.

Lamp Replacement. The graticule illumination lamps are bayonet Type 47, 6-8 volt bulbs. Remove the four bezel nuts, lift away the graticule, and replace the lamps in the normal manner.

The four neon bulbs just to the left of the crt (two are not visible through the front panel) are soldered in place. Removal and replacement require a small iron and long nose pliers.

Recalibration

To assure accurate measurements check the calibration of this instrument after each 500 hours of operation or every six months if used intermittently. Complete calibration instructions are given in Section 5.

The calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles, not apparent during normal use, may be revealed and/or corrected by recalibration.

Cleaning

The Type RM529 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides a possible electrical conduction path.

Loose dust accumulated on the outside of the Type RM529 can be removed with a cloth or small paint brush. The paint brush is particularly useful for dislodging dust on and around the front-panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild solution of water and detergent. Abrasive cleaners should not be used.

The high-voltage circuits, including parts located under the high-voltage shield, should receive special attention. Excessive dust and dirt in these areas may cause high-voltage arcing and result in improper instrument operation.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Some chemicals to avoid are benzene, toluene, xylene, acetone, or similar solvents.

To clean the graticule and the face of the crt, first remove the four graticule nuts. Then remove the graticule bezel and the graticule. Clean the graticule and the face of the crt with a soft, lint-free cloth dampened with mild detergent and water. Repeat with a cloth dampened with water only.

Standard Parts

All electrical and mechanical part replacements for the Type RM529 can be obtained through your local Tektronix Field Office or representative. However, since many of the electronic components are standard parts, they can generally be obtained locally in less time than is required to order them from the factory. Before purchasing replacement parts, consult the Parts List for value, tolerance rating and Tektronix Part Number.

Special Parts

In addition to the standard electronic components, some special parts are used in the production of the Type RM529. These parts are manufactured or selected by Tektronix to meet specific performance requirements, or are manufactured for Tektronix in accordance with our specifications. Most of the mechanical parts used in this instrument have been manufactured by Tektronix. These special parts are indicated in the Parts List by an asterisk preceding the part number. Order all special parts directly from your Tektronix Field Office or representative.

Resistor Coding

The Type RM529 uses a number of vary stable metal film resistors identified by their gray background color and color coding.

If the resistor has three significant figures with a multiplier, the resistor will be EIA color coded. If it has four significant figures with a multiplier, the value will be printed on the resistor. For example, a 333 k resistor will be color coded, but a 333.5 k resistor will have its value printed on the resistor body.

The color coding sequence is shown in Fig. 4-2, and Table 4-2.

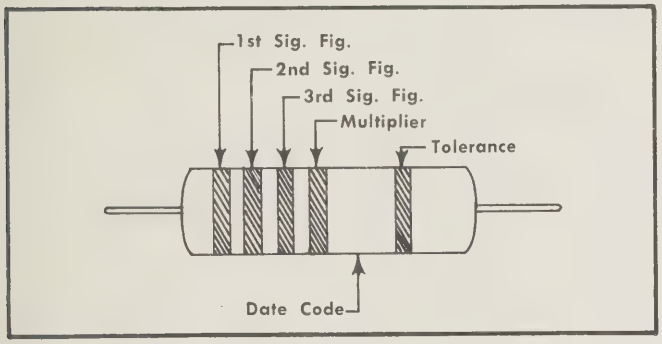


Fig. 4-2. Standard EIA color code for metal film resistors.

TABLE 4-2

Color Code Sequence

COLOR	1ST SIG. FIG.	2ND SIG. FIG.	3RD SIG. FIG.	MULTIPLIER	(±) % TOLERANCE
Black	0	0	0	1	—
Brown	1	1	1	10	1
Red	2	2	2	100	2
Orange	3	3	3	1,000	—
Yellow	4	4	4	10,000	—
Green	5	5	5	100,000	0.50
Blue	6	6	6	1,000,000	0.25
Violet	7	7	7	10,000,000	0.10
Gray	8	8	8	100,000,000	0.05
White	9	9	9	1,000,000,000	—
Gold				0.1	5
Silver				0.01	—
No Color					10

Ceramic Terminal Strip Replacement

A complete ceramic terminal strip assembly is shown in Fig. 4-3. Replacement strips (including studs) and spacers are supplied under separate part number. The old spacers may be reused unless they are damaged.

After the damaged strip has been removed, place the undamaged spacers in the chassis holes. Then, carefully press the studs into the spacers until they are completely seated. If necessary, use a soft mallet and tap lightly, directly over the stud area of the strip.

Soldering

Ceramic Terminal Strips. Solder used on the ceramic terminal strips should contain about 3% silver. Ordinary 60-40 solder can be used occasionally without damage to the ceramic terminal strips. Use a 40- to 75-watt soldering iron with a 1/8" wide chisel-shaped tip. If ordinary solder is used repeatedly or if excessive heat is applied, the solder-to-ceramic bond can be broken.

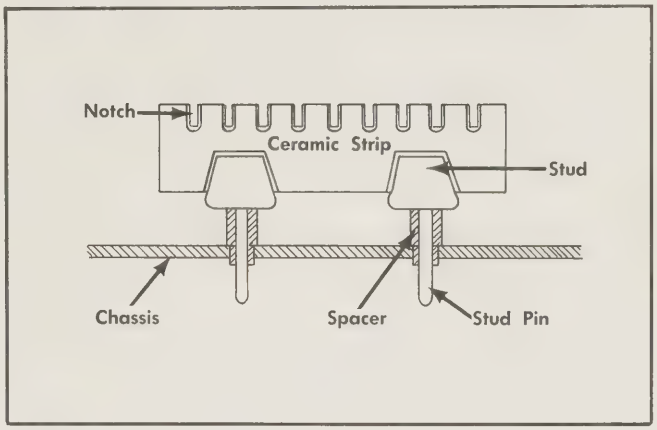


Fig. 4-3. The ceramic strip and its parts.

A small supply of solder containing about 3% silver is included on a spool mounted inside this instrument on the rear panel. Additional solder should be available locally, or it can be purchased from Tektronix in one-pound rolls; order by Tektronix Part Number 251-514.

Observe the following precautions when soldering ceramic terminal strips:

1. Use a hot iron for a short time. Apply only enough heat to make the solder flow freely.

2. Maintain a clean, properly tinned tip.

3. Avoid putting pressure on the ceramic terminal strip.

4. Do not attempt to fill the terminal-strip notch with solder; use only enough solder to cover the wires adequately.

Metal Terminals. When soldering metal terminals (e.g., switch terminals, potentiometers, etc.), ordinary 60/40 solder can be used. The soldering iron should have a 40- to 75-watt rating with a 1/8" wide chisel-shaped tip.

Observe the following precautions when soldering metal terminals:

1. Apply only enough heat to make the solder flow freely.

2. If a wire extends beyond the solder joint, clip the excess close to the joint.

3. Apply only enough solder to form a solid connection. Excess solder may impair the function of the part.

Rotary Switches

Individual wafers or mechanical parts of rotary switches are normally not replaced. If a switch is defective, replace

the entire assembly. The availability of replacement switches, either wired or unwired, is detailed in the Parts List.

Cathode-Ray Tube

Use the following procedure for removal and replacement of the crt:

WARNING

Use care when handling a crt. Avoid striking it on any object that might cause it to crack and implode. Flying glass from an imploding crt can cause serious injury. Wear safety glasses or a plastic face mask.

1. Disconnect the instrument power.

2. Place the instrument on a level workbench.

3. Remove the graticule.

4. Carefully remove the five neck-leads. Use long nose pliers and slowly pull each clip off its neck pin.

5. Loosen the 10-32 bolt in the white plastic crt rear neck clamp.

6. Place one hand over the crt face. With the other hand push gently on the crt socket until the tube moves slightly forward. Remove the socket and push on the center of the crt base. Carefully guide the tube out the front, so as to not touch the magnetic shield with the neck pins.

To install a new crt:

1. Position the tube with the single neck pin at the top, two neck pins at both the side and bottom.

2. Carefully insert the tube into the magnetic shield, being careful not to touch the shield with the neck pins.

3. Extend the finger of one hand into the rear end of the shield to help guide the base into place. Push the crt the last 1/4 inch with the plastic graticule so the front of the tube is flush with the front panel.

4. Tighten the 10-32 bolt in the plastic clamp until the crt neck is held firmly. DO NOT OVERTIGHTEN.

5. Use long nose pliers and carefully install the neck clips to the neck pins; observe the color code as marked on the shield near each opening.

6. If the crt face is not parallel with the front panel, use a 7/64" allen wrench to loosen the two blued bolts at the mounting clamp. Raise, lower, or otherwise position the crt socket so the face is correctly positioned. Tighten the blued bolts and check that the neck pins are not grounded.

7. Reinstall the graticule and recalibrate the instrument per the Calibration Procedure.

Troubleshooting

In the event of trouble, help with the particular problem may be obtained by reading the circuit description. Voltage checks and normal troubleshooting procedures will lead to the trouble and its correction.

Power Supply Problems. The Type RM529 can still present a display and appear to operate if certain problems develop in the power supplies. The following symptoms and their related causes will help solve power supply failures.

TABLE 4-3

Problem	Probable Cause
1. Short sweep, excess high voltage and ripple horizontally.	Q647 or Q644 of +100-Volt supply is shorted.
2. Same as No. 1; in addition, Calibrator waveform shows considerable hum.	Q637 or Q634 of —25-Volt supply is shorted.
3. No trace. No heater glow in two 12AT7 tubes. POWER ON neon still glows.	Q637 or Q634 of —25-volt supply are open or F637 is blown. Or if 12AT7 heaters glowing, V833-V832 filaments open, look for their glow.
4. Sweep shortens as INTENSITY control is turned CW.	V800A has a short, or V800B has a short, or Q804 is shorted.

SECTION 5

CALIBRATION

Introduction

The Type RM529 Waveform Monitor is a stable instrument which will provide many hours of trouble-free operation. However, to insure measurement accuracy, it is suggested that you recalibrate the instrument after each 500 hours of operation, or every six months if used intermittently. It will also be necessary to recalibrate certain sections of the instrument when tubes, transistors or other components that affect the calibration accuracy of the instrument are replaced.

In the instructions that follow, the steps are arranged in proper sequence for full calibration and checking the operational standards of the instrument. Each step beginning with the word "Adjust" contains the information necessary to make one or more adjustments. Steps which begin with the word "Check" are included so that you may check the operational standards, if desired.

If a complete calibration is not necessary, you may perform individual "Adjust" steps, providing that the steps performed do not affect other adjustments. It is most important that you are fully aware of the interaction of adjustments. Generally speaking, the interaction of controls will be apparent by referring to the schematic diagrams. If you are in doubt, check the calibration of the entire section on which you are working.

If any repair or adjustment is made in the low-voltage or high-voltage power supplies, you will have to check the calibration of the entire instrument.

Equipment Required

The following equipment, or equivalent, is required to perform a complete calibration of the instrument.

1. VOM (Volt-Ohm-Milliammeter) having a sensitivity of at least 20,000 Ω/v and calibrated for an accuracy of at least 1% at 25 and 100 volts, and for an accuracy of at least 3% at 5300 volts. Portable multimeters should be regularly checked against an accurate standard and corrected readings noted, where necessary, at the above listed voltages.

2. Sine-wave generator, Tektronix Type 190B Constant-Amplitude Signal Generator. Required specifications: Output frequencies of 50 kc, and a variable range from 350 kc to 10 mc; output amplitude 200 mv to 1 volt adjustable (manually or automatically) for constant amplitude at the frequencies stated.

3. Test Oscilloscope with 1X or 10X passive probes. Description: Bandwidth, 8 cps to 1 mc or better; calibrated deflection factor of 5 mv/cm and 5 volts/cm. Purpose: To perform steps 2 and 21 in the Calibration Procedure.

4. Standard Square-Wave Calibrator. Frequency approximately 1 kc; 0.2, 0.5 and 1 volt peak-to-peak output amplitudes within an accuracy of 0.2%. Special item. As a substitute, the 1-kc Amplitude Calibrator in a Tektronix oscilloscope can be used.

5. Time-mark generator, Tektronix Type 180A Time-Mark Generator. Required specifications: Time marker intervals of 1 μsec, 5 μsec and 10 μsec; sine-wave output of 5 mc. (If the Type 180A is used, a 5X attenuator is needed to attenuate the signal for application to the Type RM529.) Trigger rate output of 10 kc and 1 kc.

6. An accurate rms-reading ac voltmeter, having a range of 0-150 volts (0-250 or 0-300 for 230-volt operation). Used for monitoring the line voltage.

7. Variable autotransformer having a rating of at least 1 ampere at 115 volts.

8. Composite video signal source; calibrated signal amplitude of 1 volt, variable from 200 mv to 1 volt.

9. Termination, 75-ohm, equipped with a UHF plug connector, Tektronix Part No. 011-023.

10. Two coaxial cables, 75-ohm (nominal impedance), 42" long, equipped with UHF plug connectors on each end, Tektronix Part No. 012-002.

11. Two BNC male to UHF female connector adapters, Tektronix Part No. 103-032. Each adapter is fitted with a BNC male and a UHF female connector.

12. Staircase Generator, output amplitude 12 volts peak-to-peak. See Operating Instructions section of this manual for connector wiring, since the signal must be applied through a connector plug to J501 (rear panel) connector and the relay K385 should be actuated to perform step 29.

13. Suggested tools:

1—Screwdriver, shank about 3" long by 3/16" tip.

1—Screwdriver, shank about 2" long by 3/32" wide tip.

1—Insulated low-capacitance screwdriver, Jaco No. 125, 1½" long shank by ⅛" wide metal tip. Tektronix Part No. 003-000.

1—Hexagonal wrench 5" long, for 0.100" inside diameter powered iron hex slugs. Tektronix Part No. 003-301.

PRELIMINARY INSTRUCTIONS

The instrument should be removed from any enclosure, the top and bottom dust covers removed, so as to provide easy access to all internal adjustments and test points, including rear-panel connectors. Check that a 140-IRE unit composite graticule (331-145) is installed because this one is used in the procedure.

Set the Type RM529 front-panel controls as follows:

POWER	OFF
FOCUS	Midrange
INTENSITY	Fully counterclockwise
SCALE ILLUM	2/3 clockwise

VERTICAL Controls

INPUT	CAL
POSITION	Midrange
RESPONSE	FLAT
MAG	X1
VARIABLE (MAG)	CAL (fully clockwise so switch is actuated)
DC RESTORER	OFF
CALIBRATOR	F.S.
GAIN	Midrange

HORIZONTAL Controls

POSITION	Midrange (five full turns from either end)
DISPLAY	2 FIELD
MAG	X1
DELAY	Midrange (five full turns from either end)
FIELD SHIFT	ODD
SYNC	INT

NOTE

Figs. 5-8 through 5-11 on a fold-out page preceding the schematics show the location of each internal calibration control and test point used in the calibration procedure.

Before applying power to the instrument, check the resistances of the power supplies. Typical resistance readings are listed in Table 5-1. Locations of the test points are shown in Fig. 5-8.

TABLE 5-1

Typical Resistances of Power Supplies

Supply	Ohmmeter Range	Approx. Resistance*
—25 v	X1	25 Ω, 13 Ω
+100 v	X1k	2.3 k, 2.1 k
+360 v unreg	X1k	10 k, 100 k

***VOM leads connected one way and then the other way to get both readings. These readings were obtained using a 20,000 Ω/v VOM.**

Connect the power cord and the ac voltmeter to the output of the autotransformer. Turn on the POWER switch and adjust the autotransformer for an output voltage to match the design center voltage of the instrument. Allow the instrument to warm up for several minutes before proceeding with the calibration adjustments. During calibration, periodically check the ac line voltage to the instrument and adjust the autotransformer as necessary to maintain the voltage at the design center voltage except when the power supply regulation and ripple are being checked.

CAUTION

Do not reset the —25 VOLTS/CAL AMPL R620 unless the power supply voltages are actually out of tolerance or you are planning to perform a complete calibration of the instrument.

PROCEDURE

1. Adjust —25 VOLTS/CAL AMPL

a. Connect a VOM between the —25 v supply and ground.

b. Adjust the —25 VOLTS/CAL AMPL R260 control (see Fig. 5-8) for a meter reading of —25 volts.

c. Connect a 1-v peak-to-peak signal from a Standard Calibrator to the EXT CAL INPUT connector on the rear panel.

d. Advance the INTENSITY control so the display is of suitable brightness.

e. Set the (VERTICAL) POSITION control to center the display.

f. Adjust the (HORIZONTAL) POSITION control so the display starts at the left side of the graticule (0-cm graticule marking).

g. Adjust the FOCUS control to obtain a well-defined display.

h. Set the VARIABLE (MAG) control for exactly 140 IRE units of vertical deflection.

i. Set the CALIBRATOR switch to EXT and reset the —25 VOLTS/CAL AMPL control for exactly 140 IRE units of vertical deflection.

NOTE

In this and remaining steps, when necessary, use the (VERTICAL) POSITION control for positioning the display or trace for best alignment of display with the graticule lines.

j. Set the CALIBRATOR switch to F.S. and repeat steps 1h through 1j until no further adjustment is required.

k. Disconnect the calibrator signal.

2. Check Low-Voltage Power-Supply Regulation and Ripple

a. Set the CALIBRATOR switch to .714 F.S. to display 100 IRE units of vertical deflection.

b. Vary the autotransformer so the line voltage is set 10% above design center (for 115 v, +10% is 126.5 v) and hold for 1 minute at this voltage extreme. Check voltage regulation and ripple according to the information given in Table 5-2.

c. Vary the autotransformer so the line voltage is set 10% below design center (for 115 v, —10% is 103.5 v) and hold for 1 minute at this voltage extreme. Check voltage regulation and ripple as given in Table 5-2.

TABLE 5-2

Typical Ripple Amplitudes

Supply	Voltage Deviation*	Ripple Amplitude
—25 v	≤ ±3% or 0.75 v	≤ 10 mv
+100 v	≤ ±5% or 5 v	≤ 100 mv

***Deviation from the voltage reading obtained at design center; for example, if —25 v supply indicates a reading of —25.7 v on the VOM at design center, deviation should be within the range from —24.95 v to —26.45 v.**

d. Set the autotransformer for design center line voltage.

e. Disconnect the VOM and 1X probe.

3. Adjust HIGH VOLTAGE R835

a. Connect the VOM between the crt cathode (see Fig. 5-10) and ground.

b. Adjust the HIGH VOLTAGE R835 control (see Fig. 5-11) to obtain a meter reading of —5300 v.

4. Check High Voltage Regulation

a. Vary the autotransformer so the line voltage is set 10% above design center and hold for 1 minute at this extreme. Check that the high voltage remains essentially constant (within ±5% or 265 volts of the —5300-volt reading).

b. Vary the autotransformer so the line voltage is set 10% below design center and hold for 1 minute at this extreme. Check that the high voltage remains essentially constant (within ±5% or 265 volts of the —5300-volt reading).

c. Set the autotransformer for design center line voltage.

d. Disconnect the VOM.

5. Adjust ASTIG R864

a. Set the DISPLAY switch to 2 LINE.

b. Adjust the FOCUS and ASTIG R864 (see Fig. 5-11) controls to obtain a well-defined display using normal brightness.

6. Adjust CRT BEAM ROTATOR R655

a. Set the DISPLAY switch to 2 FIELD.

b. Adjust the CRT BEAM ROTATOR R655 control (see Fig. 5-11) so the flat bottom of the calibrator square waves coincide with the graticule line.

7. Adjust DC BAL R115

a. Set the INPUT switch to A (no signal applied to VIDEO INPUT A connector).

b. Adjust the DC BAL R115 control (see Fig. 5-11) for no vertical movement of the trace as (VERTICAL) MAG switch is set to X2, to X5, and then returned to X1. Repeat this procedure, if necessary, to check that the adjustment is made properly.

8. Adjust VAR DC BAL R130

a. Check that the (VERTICAL) MAG switch is set to X1.

b. Adjust the VAR DC BAL R130 control (see Fig. 5-11) for no vertical movement of the trace as the (VERTICAL) VARIABLE control is rotated from extreme to extreme.

c. Set the (VERTICAL) VARIABLE control to the CAL position.

9. Adjust VERT GAIN R169

a. Connect a 1-v peak-to-peak signal from the Standard Calibrator to the upper A VIDEO INPUT connector.

b. Adjust the VERT GAIN R169 control (see Fig. 5-11) to obtain exactly 140 IRE units of vertical deflection.

10. Adjust Vertical X5 MAG GAIN R119

a. Set the Standard Calibrator for 0.2-v peak-to-peak output.

b. Set the (VERTICAL) MAG switch to X5.

c. Adjust the X5 MAG GAIN R119 control (see Fig. 5-11) for exactly 140 IRE units of vertical deflection.

11. Check Vertical X2 Magnifier Gain Accuracy

a. Set the (VERTICAL) MAG switch to X2.

b. Set the Standard Calibrator for 0.5-v peak-to-peak output.

c. Check that the vertical deflection of the display is 140 IRE units within a tolerance of ±4 IRE units.

12. Check Vertical Calibration Accuracy

a. Set the CALIBRATOR switch to F.S. and the INPUT switch to CAL.

b. Check for a vertical deflection of 140 IRE units as the (VERTICAL) MAG switch is set to X1, X2 and X5.

13. Check B Input

a. Disconnect the calibrator signal from the Upper A VIDEO INPUT connector and apply the calibrator signal to the upper B VIDEO INPUT connector.

b. Set the Standard Calibrator for 1-v peak-to-peak output amplitude.

c. Set the (VERTICAL) MAG switch to X1 and the INPUT switch to B.

d. Check for 140 IRE units of vertical deflection.

e. Disconnect the calibrator signal from the B VIDEO INPUT connector.

14. Adjust TRIG MULTI BIAS R325

a. Connect a composite video signal to the lower EXT NEG SYNC INPUT connector.

b. Connect a coaxial cable from the upper EXT NEG SYNC INPUT connector to the upper A VIDEO INPUT connector.

c. Connect a 75-ohm termination to the lower A VIDEO INPUT connector.

d. Set the Type RM529 front-panel controls as follows:

INPUT	A
(VERTICAL) MAG	X5
DISPLAY	2 FIELD

e. Adjust the source signal level to produce 40 IRE units of sync amplitude.

f. First, rotate the TRIG MULTI BIAS R325 control (see Fig. 5-11) fully counterclockwise. Then, rotate the control slowly clockwise until the display is synchronized; that is, a stationary display is obtained.

NOTE

If the Type RM529 is used to monitor video signals containing noise, rotate the TRIG MULTI BIAS control about 20° further clockwise from the point where a stable display was first obtained. If the control is turned too far clockwise, a jittery display will be obtained. The control should always be set within the stable display range.

g. As a check that the TRIG MULTI BIAS control is properly adjusted, set the (VERTICAL) MAG switch to X1 and adjust the source signal level for a larger sync amplitude (up to 40 IRE units) and check that the display remains synchronized.

15. Check External Sync

a. Set the SYNC switch to EXT.

b. Set the (VERTICAL) MAG switch to X2.

c. Adjust the video source signal level so the vertical deflection is 20 IRE units of sync amplitude.

d. Check that a stable display is obtained.

e. Disconnect the video signal from the lower EXT NEG SYNC INPUT connector.

f. Disconnect the jumper coaxial cable.

16. Check DC RESTORER switch

a. Set the front-panel controls to these settings:

(VERTICAL) MAG	X1
DC RESTORER	ON
CALIBRATOR	.714 F.S.
SYNC	INT

b. Using the (VERTICAL) POSITION control, position the bottom of the calibrator waveform so it coincides with the 0 IRE graticule line.

c. Set the (VERTICAL) MAG switch from X1 to X2, to X5. Check for ±4 IRE units or less vertical movement of the calibrator waveform from 0 IRE.

d. Set the (VERTICAL) MAG switch to X1 and DC RESTORER switch to OFF.

17. Adjust HORIZ GAIN R568

a. Connect 5-μsec and 10-μsec time markers from the Type 180A to the upper A VIDEO INPUT connector.

b. Check that the termination is still connected to the lower A VIDEO INPUT connector.

c. Apply 10-kc trigger signals from the Type 180A to the upper EXT NEG SYNC INPUT connector.

d. Set the SYNC switch to EXT and the DISPLAY switch to .125 H/CM.

e. Up to this point in the procedure check that these remaining front-panel controls are set as follows:

VERTICAL Controls

INPUT	A
POSITION	Near midrange
RESPONSE	FLAT
MAG	X1
VARIABLE (MAG)	CAL
DC RESTORER	OFF
CALIBRATOR	.714 F.S.

HORIZONTAL Controls

POSITION	Near midrange
MAG	X1
DELAY	Midrange
FIELD SHIFT	ODD

f. Check the display. If the markers overscan the screen, insert a 5X attenuator in series with the cable which connects to the A VIDEO INPUT connector.

NOTE

Use the (VERTICAL) MAG and VARIABLE controls to adjust the vertical amplitude of the display in steps 17 through 20.

g. Adjust the HORIZ GAIN R568 control (see Fig. 5-11) for a sweep length of 10.2 cm.

18. Adjust Miller Timing Capacitor C481

Adjust the Miller timing capacitor C481 (see Fig. 5-11) for 80 μsec per 10 cm (see Fig. 5-1).

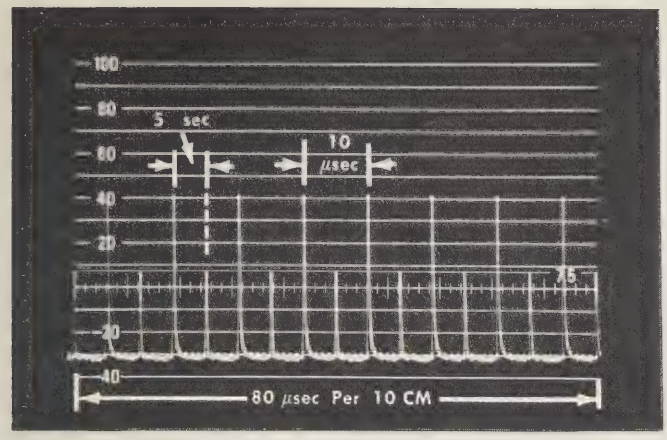


Fig. 5-1. Adjusting C481 for correct X1 sweep timing.

19. Adjust X25 Horizontal Sweep Magnifier Capacitor C521

a. Set the Type 180A for 5-mc sine-wave output.

b. Set the (HORIZONTAL) MAG switch to X25.

c. Adjust the horizontal sweep magnifier capacitor C521 (see Fig. 5-10) primarily for sweep timing and secondarily for linearity. For correct timing, 16 sine waves per 10 cm should be displayed (see Fig. 5-2). For checking linearity, display should show 4 sine waves for any 2.5-cm portion of the display.

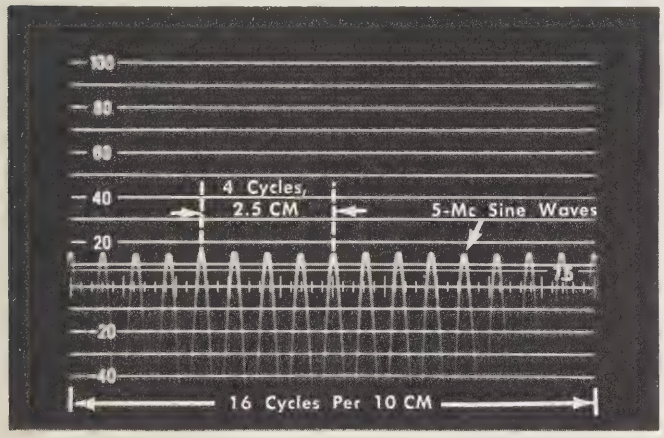


Fig. 5-2. Adjusting C521 for optimum X25 sweep linearity.

NOTE

To minimize horizontal jitter, use the Type RM529 top and bottom covers to shield the high-voltage compartment but leave an opening so C521 can be adjusted. Also, set the Type 180A trigger rate for 1-kc trigger output. After completing this step, set trigger rate to 10 kc.

20. Check X5 Magnified Sweep Timing

a. Set the Type 180A output for 1-μsec time marker output and check that the trigger rate is 10 kc.

b. Set the (HORIZONTAL) MAG switch to X5.

c. Check for 16 μsec of sweep time per 10 cm (see Fig. 5-3). Sweep timing tolerance should be within ±3 mm.

d. Disconnect the time markers and external trigger.

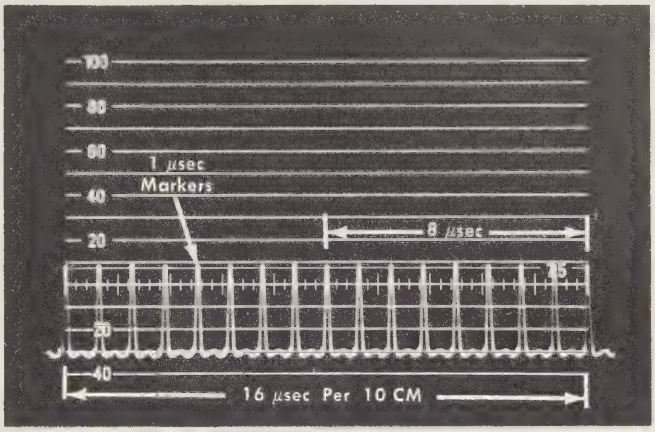


Fig. 5-3. Checking the X5 sweep timing.

21. Adjust EVEN FIELD SYNC R360

a. Connect 1-volt composite video signal to the upper A VIDEO INPUT connector.

b. Check that a 75-ohm termination is connected to the lower A VIDEO INPUT connector.

c. Set the Type RM529 front-panel controls as follows:

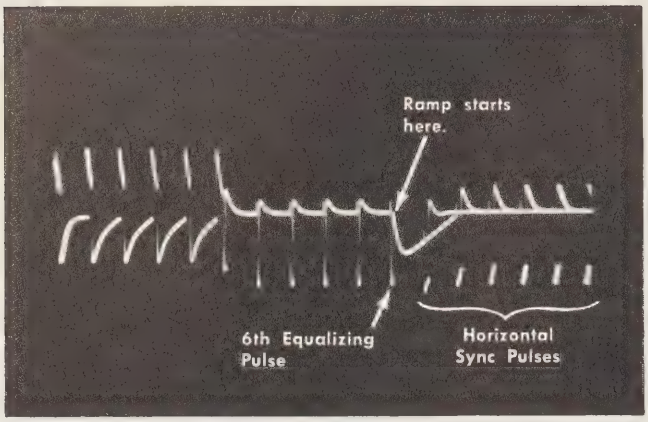
(VERTICAL) MAG	X1
(VERTICAL) VARIABLE	CAL
DC RESTORER	ON
MAG (HORIZONTAL)	X25
DISPLAY	2 FIELD
SYNC	INT

d. Set the test oscilloscope controls as follows:

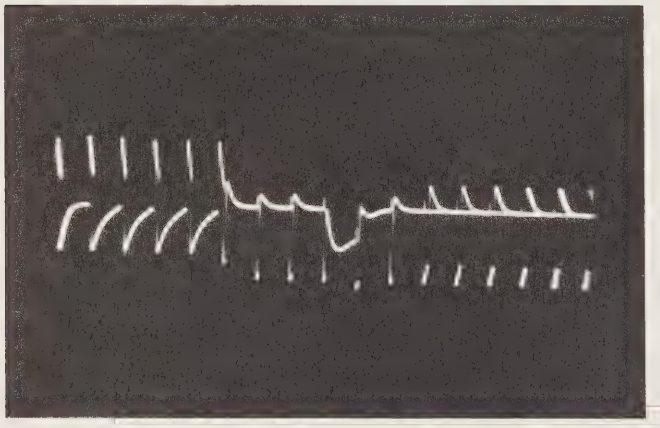
Sweep Rate	50 μSec/Cm
Triggering	+Int, AC
Signal Input Coupling	AC
Vertical Deflection Factor (with 10X attenuator probe)	5 Volts/Cm

e. Connect the 10X probe tip to the junction of D370 and C370 (see Fig. 5-9).

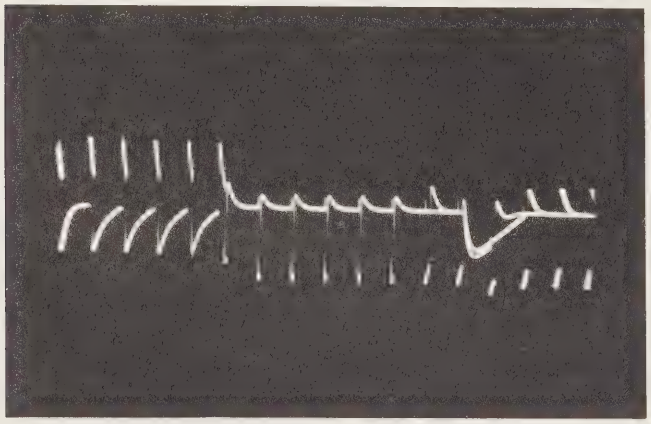
f. Rotate the EVEN FIELD SYNC R360 control (see Fig. 5-11) fully counterclockwise. Then, rotate the control slowly in a clockwise direction until the ramp starts just after the 6th equalizing pulse (see Fig. 5-4a). The 6th equalizing pulse is the last pulse in the equalizing-pulse group that follows the vertical sync pulses. Figs. 5-4b and 5-4c show two possible displays that can be obtained when the control is **incorrectly** adjusted.



(a) Correct display.



(b) Incorrect display; control R360 set too far counterclockwise.

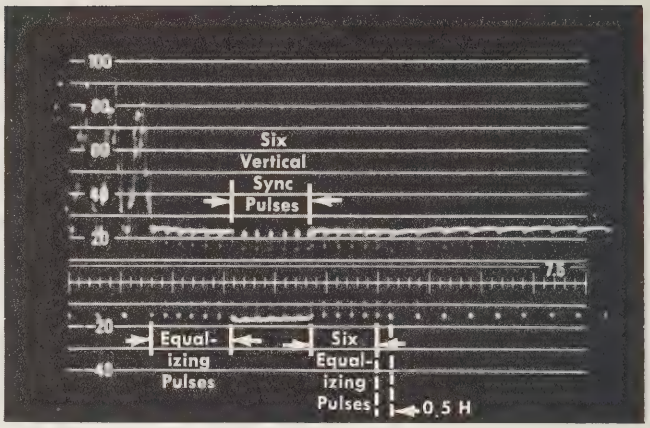


(c) Incorrect display: control R360 set too far clockwise.

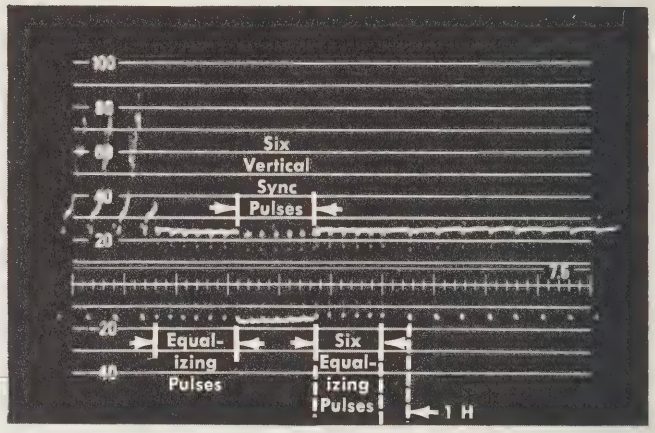
Fig. 5-4. Adjusting the EVEN FIELD SYNC R360 control for proper triggering. Displays obtained on the test oscilloscope crt.

NOTE

Use the Type RM529 top and bottom dust covers for this step and step 22 to shield the high-voltage compartment but leave space so the test point and adjustment can be reached.



(a) FIELD switch set to EVEN.



(b) FIELD switch set to ODD.

Fig. 5-5. Checking for proper field display when operating the FIELD and SYNC switches.

g. Disconnect the 10X probe.

22. Check FIELD Switch

a. Set the FIELD switch to EVEN.

b. Check for a horizontal distance of 0.5 H (31.75 μsec) between the 6th equalizing pulse and the first horizontal sync pulse (see Fig. 5-5a). This indicates that an even field is displayed.

NOTE

When counting the number of equalizing pulses occurring after the vertical sync pulse group, the first equalizing pulse is difficult to find because it is located so close to the last vertical sync pulse. To locate the first equalizing pulse, first find the trailing edge of the 6th vertical sync pulse. Then, find the first equalizing pulse which begins its rise just after the 6th vertical sync pulse (see Fig. 5-5a).

c. Set the SYNC switch to EXT and back to INT several times to check that an even field display is obtained each time the SYNC switch is returned to the INT position. This is a double check on step 21. A stable display of an even field means that R360 is adjusted properly.

d. Set the FIELD switch to ODD.

e. Check for 1 H (63.5 μsec) horizontal distance between the 6th equalizing pulse and the first horizontal sync pulse (see Fig. 5-5b). This indicates that an odd field is displayed.

f. Repeat step 22c except check that an odd field display is obtained each time the SYNC switch is returned to INT.

23. Adjust SW/MAG REGIS R575

a. Using the (HORIZONTAL) POSITION control, position the display so the center of the vertical-sync pulse group coincides with graticule center (see Fig. 5-6a).

b. Set the HORIZONTAL MAG switch to X1.

c. Adjust the SW/MAG REGIS R575 control (see Fig. 5-11) so the vertical pulse group coincides with graticule center (see Fig. 5-6b).

d. To check if the adjustment has been set properly, set the (HORIZONTAL) MAG switch to X25 and then to X1. If the display as observed at graticule center shifts horizontally, readjust the SW/MAG REGIS R575 control for no horizontal shift of the display when switching for X25 to X1.

e. Disconnect the composite video signal.

24. Check Vertical Amplifier High-Frequency Response

a. Apply a 50-kc sine-wave signal from the Tektronix Type 190B, or equivalent, to the A VIDEO INPUT connector. (Connect the Type 190B attenuator head directly to the A VIDEO INPUT connector.)

b. Set the DC RESTORER switch to OFF. Check that the (HORIZONTAL) MAG switch is set to X1 and the DISPLAY switch is set to 2 FIELD.

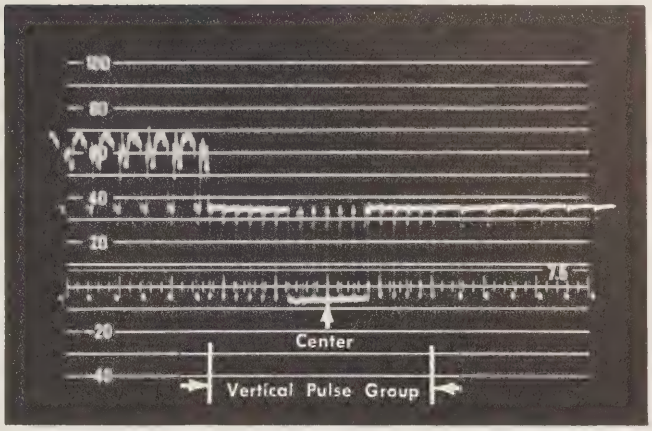
c. With the front-panel controls set as given in the top line of Table 5-4 on page 5-8, adjust the Type 190B for 100 IRE units of vertical deflection. This is the reference amplitude.

d. Follow the remaining sequence of instructions given in Table 5-4 to check the vertical-amplifier frequency response and rolloff for all the front-panel control positions listed.

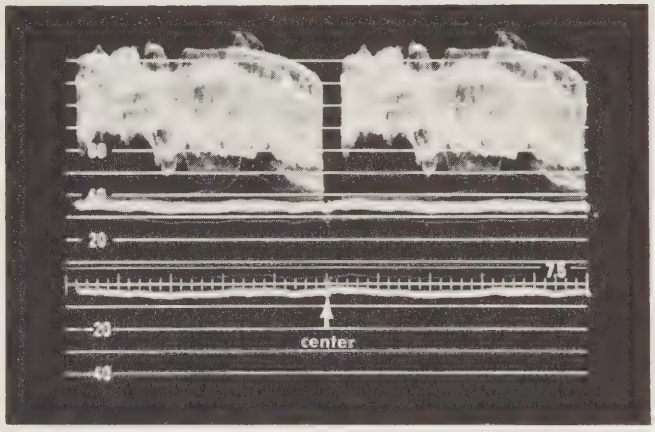
25. Adjust Vertical-Amplifier X1 Flat-Frequency Response—C269, L162 and L262

Using the same setup conditions as described in steps 24a through 24c, adjust the vertical-amplifier components as listed in Table 5-3 to obtain flat frequency response from 500 kc to 8 mc within ±1% to 5 mc, ±3% to 8 mc. Locations of these adjustments are shown in Fig. 5-11. Since the adjustments interact, repeat as necessary to obtain the desired flat frequency response.

Add adjustment C133 which affects the vertical amplifier flat-frequency response in the 5 to 8 mc region.



(a) HORIZONTAL MAG switch set to X25.



(b) HORIZONTAL MAG switch set to X1.

Fig. 5-6. Adjusting the SW/MAG REGIS R575 control for proper display registration.

TABLE 5-3

Vertical Amplifier Flat Frequency Response Adjustments

Adjustment	Affects Frequency Response In These Frequency Ranges
C269	2 to 6 mc, particularly at 2.5 mc
Physical spacing of R162 and R262	3 to 6 mc, particularly at 4 mc
L162 and L262 Top and Bottom Slugs	Top[1] slugs: 7 mc and up Bottom[2] slugs: 5 to 10 mc

[1] **Normal position for the top slugs is flush with the top of the coil form.**

[2] **Normal position for the bottom slugs is as follows: screw slugs to bottom of coil form and then bring slugs 6 turns up from the bottom.**

Adjust C133 so the frequency response is down approximately 1% from the response at the 5-mc point. C133 is located on the (VERTICAL) RESPONSE switch.

C133 interacts with the other adjustments in step 25; therefore, it is necessary to recheck the response between 500 kc and 8 mc at several points to determine if any of the other adjustments in the step need to be readjusted to obtain the desired response.

TABLE 5-4

Checking Vertical Amplifier Frequency Response

RESPONSE Switch Set To:	Signal[1] To: INPUT Switch Set To:	(VARIABLE) MAG Set To:	(VERTICAL) MAG Switch Set To:	Check or Procedure
FLAT	A	CAL	X1	Check for flat frequency response from 500 kc to 8 mc[2]; within ±1% or 1 IRE unit to 5 mc, ±3% or 3 units to 8 mc.
			X2	Set Type 190B for 100 IRE units of reference amplitude at 50 kc.
			X5	
		Fully ccw	X1	Check for flat frequency response from 500 kc to 5 mc[3]; within ±3% or 3 IRE units.
	B	CAL	X1	Set Type 190B for 100 IRE units of reference amplitude at 50 kc. Check for flat frequency response from 500 kc to 8 mc; within ±1% to 5 mc, ±3% to 8 mc.
LOW PASS	A	CAL	X1	Set Type 190B for 100 IRE units of reference amplitude at 50 kc. Check for vertical deflection of 25 units or less at 500 kc.
FLAT	A	CAL	X1	[4]Set Type 190B for 100 IRE units of reference amplitude at 50 kc.
CHROMA	A	CAL	X1	Check for exactly 100 IRE units of vertical deflection at 3.58 mc (center frequency); 70 to 85 units at 3.18 mc and 3.98 mc[5].
IRE	A	CAL	X1	Set Type 190B for 100 IRE units of vertical deflection at 50 kc. Check high-frequency rolloff at the following points: At 350 kc—94 to 97.5 units. At 1 mc—70 to 80 units. At 2 mc—31.2 to 42.5 units. At 3.6 mc—7 to 14 units.

[1] **Apply the signal (via the Type 190B attenuator head directly) to the upper VIDEO INPUT connector as indicated in the column and terminate the appropriate lower VIDEO INPUT connector with a 75-ohm termination.**

[2] **If the frequency response within the tolerance specified cannot be attained, perform step 25 before completing the checks given in the remaining portion of Table 5-4.**

[3] **If the frequency response within the tolerance cannot be obtained for the X2 and X5 (VERTICAL) MAG switch positions, perform step 26 for the X2 position and step 27 for X5.**

[4] **This is a preliminary setup procedure for performing the chroma frequency response check that follows.**

[5] **If this frequency response characteristic cannot be met, perform step 28.**

26. Adjust Vertical Amplifier X2 Flat-Frequency Response—C118B

a. Set the (VERTICAL) MAG switch to X2.

b. Set the Type 190B for 100 IRE units of reference amplitude at 50 kc.

c. Adjust C118B (see Fig. 5-11) to obtain flat-frequency response from 500 kc to 5 mc within ±3%.

27. Adjust Vertical Amplifier X5 Flat-Frequency Response—C118C

a. Set the (VERTICAL) MAG switch to X5.

b. Set the Type 190B for 100 IRE units of reference amplitude at 50 kc.

c. Adjust C118C (see Fig. 5-11) to obtain flat-frequency response from 500 kc to 5 mc within ±3%.

28. Adjust Vertical-Amplifier Chroma Frequency Response—T135

a. Use the same setup conditions as described in Table 5-4, column 1, line 3. Check that the Type RM529 is displaying 100 IRE units of vertical deflection at 50 kc.

b. Set the Type 190B for an output frequency of 3.58 mc.

c. Adjust the **bottom** powdered-iron slug in T135 (see Fig. 5-11) to obtain 100 IRE units of vertical deflection.

d. Set the Type 190B for an output frequency of 3.18 mc.

e. Adjust the **top** slug in T135 to obtain 70 to 85 IRE units of vertical deflection.

f. Set the Type 190B for an output frequency of 3.98 mc.

g. Check that the vertical deflection o fthe display is 70 to 85 IRE units in amplitude. If necessary, repeat steps 28b through 28g to obtain proper chroma frequency response characteristics.

h. After completing the adjustment of T135 and the checks in Table 5-4, disconnect the Type 190B from the Type RM529.

29. Check J501 Staircase Input

a. Apply about 12 v peak-to-peak signal from a Staircase Generator to J501 connector on the rear panel.

b. Actuate relay K385.

c. Connect a 1-v peak-to-peak composite video signal to the upper A VIDEO INPUT connector.

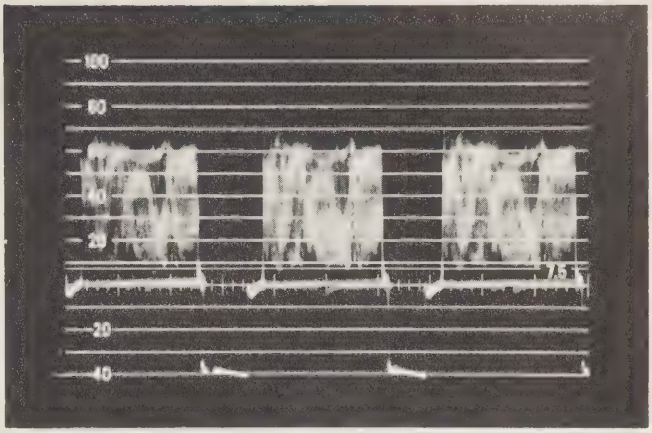


Fig. 5-7. Typical display obtained when using one type of staircase generator to check the Staircase Amplifier circuitry.

d. Check that a 75-ohm termination is connected to the lower A VIDEO INPUT connector.

e. Set the DISPLAY switch to .125 H/CM.

f. Check that the following front-panel controls are set as follows:

INPUT	A
(VERTICAL) MAG	X1
VARIABLE (MAG)	CAL
(HORIZONTAL) MAG	X1
SYNC	INT

g. Adjust the Staircase Generator output level for about 3 cm of trace separation (see Fig. 5-7).

h. Check that a 3-trace display is obtained as shown in Fig. 5-7.

NOTES

SECTION 6
PARTS LIST and DIAGRAMS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix Field Office.

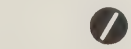
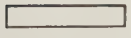
Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix Field Office will contact you concerning any change in part number.

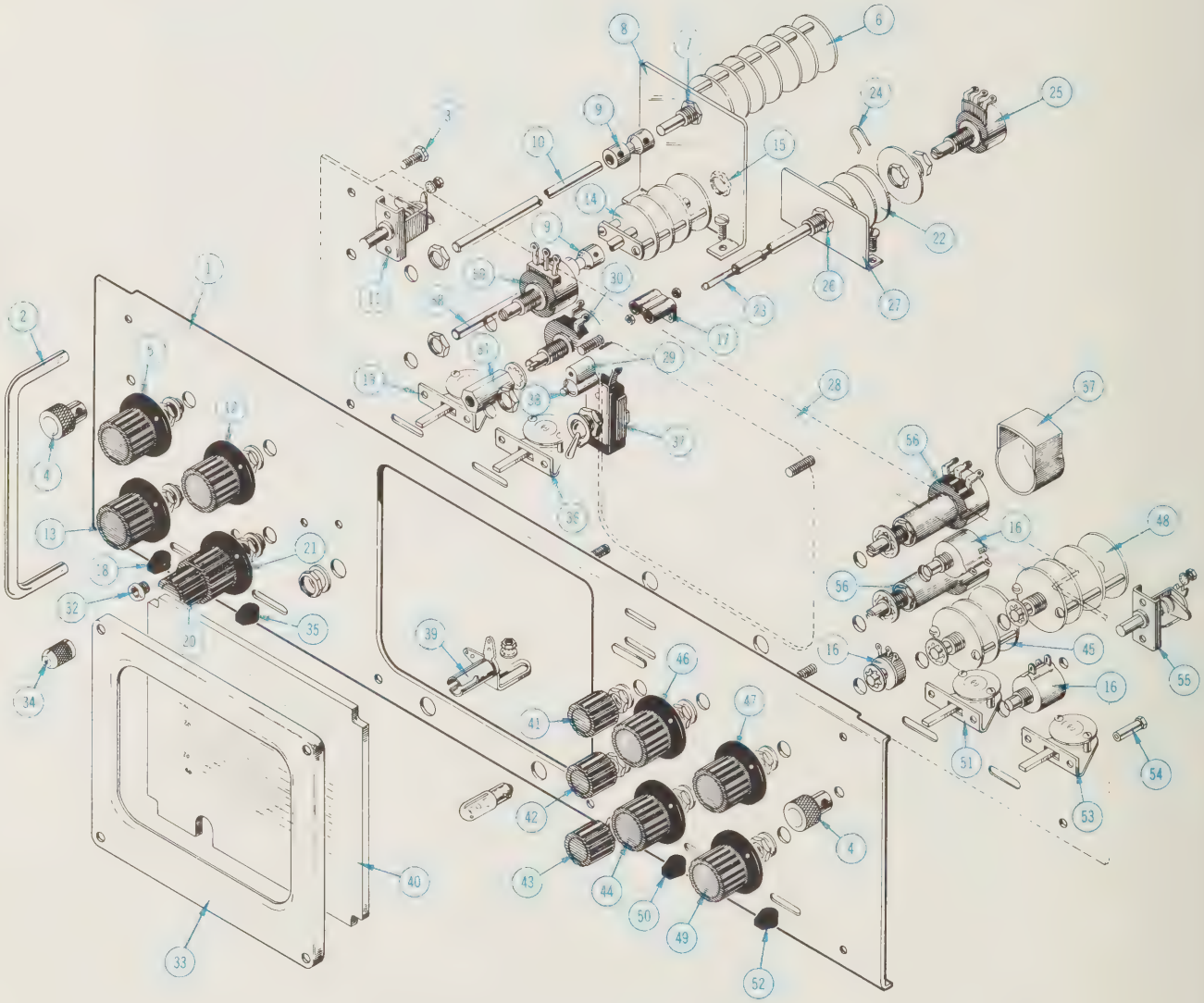
ABBREVIATIONS AND SYMBOLS

a or amp	amperes
BHS	binding head steel
C	carbon
cer	ceramic
cm	centimeter
comp	composition
cps	cycles per second
crt	cathode-ray tube
CSK	counter sunk
dia	diameter
div	division
EMC	electrolytic, metal cased
EMT	electroyltic, metal tubular
ext	external
f	farad
F & I	focus and intensity
FHS	flat head steel
Fil HS	fillister head steel
g. or G	giga, or 10^9
Ge	germanium
GMV	guaranteed minimum value
h	henry
hex	hexagonal
HHS	hex head steel
HSS	hex socket steel
HV	high voltage
ID	inside diameter
incd	incandescent
int	internal
k or K	kilohms or kilo (10^3)
kc	kilocycle
m	milli, or 10^{-3}
mc	megacycle
mm	millimeter
meg or M	megohms or mega (10^6)
met.	metal
μ	micro, or 10^{-6}
n	nano, or 10^{-9}
Ω	ohm
OD	outside diameter
OHS	oval head steel
p	pico, or 10^{-12}
PHS	pan head steel
piv	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
Prec	precision
PT	paper tubular
PTM	paper or plastic, tubular, molded
RHS	round head steel
rms	root mean square
sec	second
Si	silicon
S/N	serial number
t or T	tera, or 10^{12}
TD	toroid
THS	truss head steel
tub.	tubular
v or V	volt
Var	variable
w	watt
w/	with
w/o	without
WW	wire-wound

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.
	Front-panel adjustment or connector.

FRONT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FRONT

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	333-0863-00	100	399	1	PANEL, front
	333-0863-01	400		1	PANEL, front
2	367-0022-00			2	HANDLE, brass rod
	- - - - - -			-	mounting hardware for each: (not included w/handle)
3	213-0090-00			2	SCREW, 10-32 x 1/2 inch, HHS
4	366-0109-00			2	KNOB, plug-in securing
	- - - - - -			-	each knob includes:
	213-0005-00			1	SCREW, set, 8-32 x 1/8 inch, HSS
5	366-0173-00			1	KNOB, charcoal—VERTICAL INPUT
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
6	262-0685-00			1	SWITCH, wired—VERTICAL INPUT (See Ref. #7)
	- - - - - -			-	switch includes:
	260-0658-00			1	SWITCH, unwired—VERTICAL INPUT
7	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
8	407-0079-00			1	BRACKET, switch
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, BHS
	211-0538-00			2	SCREW, 6-32 x 5/16 inch, FHS phillips
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0457-00			3	NUT, keps, 6-32 x 5/16 inch
9	376-0011-00			2	COUPLING, insulating
	- - - - - -			-	each coupling includes:
	213-0048-00			2	SCREW, set, 4-40 x 1/8 inch, HSS
10	384-0342-00			1	ROD, extension
11	214-0425-00			1	FASTENER, left
	- - - - - -			-	mounting hardware: (not included w/fastener)
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
12	366-0173-00			1	KNOB, charcoal—VERTICAL POSITION
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
13	366-0173-00			1	KNOB, charcoal—VERTICAL RESPONSE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS

©

FRONT *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
14	262-0686-00	100	929	1	SWITCH, wired—VERTICAL RESPONSE (see ref. #15)
	262-0686-01	930		1	SWITCH, wired—VERTICAL RESPONSE (see ref. #15)
	- - - - - -			-	switch includes:
	260-0655-00			1	SWITCH, unwired—VERTICAL RESPONSE
15	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0012-00			1	LOCKWASHER, internal, $\frac{3}{8} \times \frac{1}{2}$ inch
	210-0840-00			1	WASHER, .390 ID x $\frac{9}{16}$ inch OD
	210-0413-00			1	NUT, hex, $\frac{3}{8}$-32 x $\frac{1}{2}$ inch
16	- - - - - -			3	POT
	- - - - - -			-	mounting hardware for each: (not included w/pot)
	210-0012-00			1	LOCKWASHER, internal, $\frac{3}{8} \times \frac{1}{2}$ inch
	210-0840-00			1	WASHER, .390 ID x $\frac{9}{16}$ inch OD
	210-0413-00			1	NUT, hex, $\frac{3}{8}$-32 x $\frac{1}{2}$ inch
17	352-0064-00			1	HOLDER, neon, double
	- - - - - -			-	mounting hardware: (not included w/holder)
	211-0031-00			1	SCREW, 4-40 x 1 inch, FHS
	210-0406-00			2	NUT, hex, 4-40 x $\frac{3}{16}$ inch
18	366-0215-00	100	889	1	KNOB, lever—DC RESTORER
	366-0215-01	890		1	KNOB, lever—DC RESTORER
19	260-0473-00			1	SWITCH, lever—DC RESTORER
	- - - - - -			-	mounting hardware: (not included w/switch)
	220-0413-00			2	NUT, hex, rod, 4-40 x $\frac{3}{16}$ x .500 inch
20	366-0153-00			1	KNOB, small charcoal—VARIABLE CAL
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch, HSS
21	366-0175-00			1	KNOB, charcoal—VOLTS FULL SCALE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch, HSS
22	262-0687-00			1	SWITCH, wired—VOLTS FULL SCALE (See Ref. #26)
	- - - - - -			-	switch includes:
	260-0654-00			1	SWITCH, unwired—VOLTS FULL SCALE
23	384-0260-00			1	ROD, extension
24	376-0014-00			1	COUPLING, pot
25	- - - - - -			1	POT
	- - - - - -			-	mounting hardware: (not included w/pot alone)
	210-0413-00			2	NUT, hex, $\frac{3}{8}$-32 x $\frac{1}{2}$ inch
	210-0012-00			1	LOCKWASHER, internal, $\frac{3}{8} \times \frac{1}{2}$ inch
26	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0012-00			1	LOCKWASHER, internal, $\frac{3}{8} \times \frac{1}{2}$ inch
	210-0840-00			1	WASHER, .390 ID x $\frac{9}{16}$ inch OD
	210-0413-00			1	NUT, hex, $\frac{3}{8}$-32 x $\frac{1}{2}$ inch

FRONT *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
27	407-0078-00			1	BRACKET, switch
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, BHS
	210-0803-00			2	WASHER, 6L x 3/8 inch
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
28	386-0112-00			1	PLATE, front sub-panel
29	352-0067-00			2	HOLDER, neon, single
	- - - - - -			-	mounting hardware for each: (not included w/holder)
	211-0031-00			1	SCREW, 4-40 x 1 inch, FHS
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
30	- - - - - -			1	POT
	- - - - - -			-	mounting hardware: (not included w/pot)
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
31	220-0420-00			1	NUT, adapter, hex
32	358-0054-00			1	BUSHING, banana jack
33	200-0272-00			1	COVER, graticule
	- - - - - -			-	mounting hardware: (not included w/cover)
34	210-0434-00			4	NUT, graticule
35	366-0215-00	100	889	1	KNOB, lever—CALIBRATOR
	366-0215-01	890		1	KNOB, lever—CALIBRATOR
36	260-0490-00			1	SWITCH, lever—CALIBRATOR
	- - - - - -			-	mounting hardware: (not includedw/switch)
	220-0413-00			2	NUT, hex, rod, 4-40 x 3/16 x .500 inch
37	260-0199-00			1	SWITCH, toggle—POWER ON
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0414-00			1	NUT, hex, 15/32 x 9/16 inch
	354-0055-00			1	RING, locking, switch
	210-0902-00			1	WASHER, .470 ID x 21/32 inch OD
	210-0473-00			1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided
38	378-0541-00			2	FILTER, lens, neon light
39	136-0112-00			2	SOCKET, graticule lamp
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	211-0534-00			1	SCREW, 6-32 x 5/16 inch, PHS w/lockwasher
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
	377-0064-00	X150		2	INSERT, graticule light (not shown)

FRONT *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
40	- - - - - -			1	SEE STANDARD ACCESSORIES
41	366-0148-00			1	KNOB, small charcoal—FOCUS
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
42	366-0148-00			1	KNOB, small charcoal—INTENSITY
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
43	366-0148-00			1	KNOB, small charcoal—SCALE ILLUM
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
44	366-0173-00			1	KNOB, charcoal—HORIZONTAL MAG
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
45	262-0689-00			1	SWITCH, wired—HORIZONTAL MAG
	- - - - - -			-	switch includes:
	260-0656-00			1	SWITCH, unwired—HORIZONTAL MAG
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
46	366-0173-00			1	KNOB, charcoal—HORIZONTAL POSITION
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
47	366-0173-00			1	KNOB, charcoal—HORIZONTAL DISPLAY
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
48	262-0688-00			1	SWITCH, wired—HORIZONTAL DISPLAY
	- - - - - -			-	switch includes:
	260-0657-00			1	SWITCH, unwired—HORIZONTAL DISPLAY
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
49	366-0173-00			1	KNOB, charcoal—HORIZONTAL DELAY
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
50	366-0215-00	100	889	1	KNOB, lever—FIELD SHIFT
	366-0215-01	890		1	KNOB, lever—FIELD SHIFT
51	260-0473-00			1	SWITCH, lever—FIELD SHIFT
	- - - - - -			-	mounting hardware: (not included w/switch)
	220-0413-00			2	NUT, hex, rod, 4-40 x 3/16 x .500 inch

FRONT *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
52	366-0215-00	100	889	1	KNOB, lever—SYNC
	366-0215-01	890		1	KNOB, lever—SYNC
53	260-0473-00			1	SWITCH, lever—SYNC
	- - - - - -			-	mounting hardware: (not included w/switch)
54	220-0413-00			2	NUT, hex, rod, 4-40 x 3/16 x .500 inch
55	214-0424-00			1	FASTENER, right
	- - - - - -			-	mounting hardware: (not included w/fastener)
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
56	- - - - - -			2	POT
	- - - - - -			-	mounting hardware for each: (not included w/pot)
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
57	200-0269-00			2	COVER, pot
58	384-0030-00			1	ROD, extension
59	- - - - - -			1	POT
	- - - - - -			-	mounting hardware: (not included w/pot)
	210-0207-00	X150		1	LUG, solder, 3/8 inch
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch

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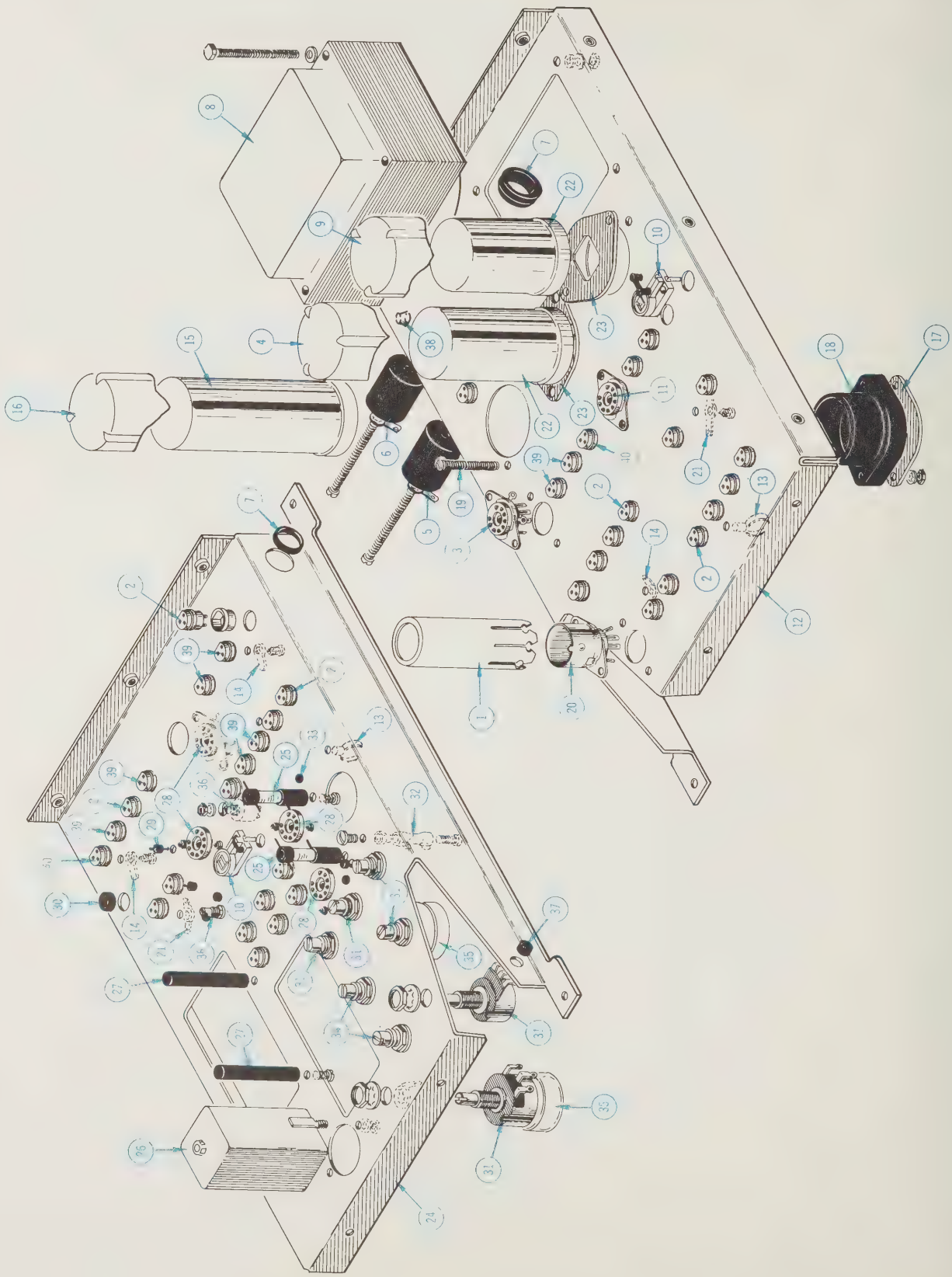
CHASSIS



CHASSIS

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	337-0491-00			1	SHIELD, tube
2	136-0181-00			33	SOCKET, 3 pin transistor
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	354-0234-00			1	RING, locking, transistor socket
3	136-0014-00			1	SOCKET, STM9
	- - - - - -			-	mounting hardware: (not included w/socket)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
4	200-0293-00			1	COVER, capacitor, 2 9/16 inches
5	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	211-0503-00			1	SCREW, 6-32 x 3/16 inch BHS
	210-0202-00			1	LUG, solder, SE #6
	210-0006-00			1	LOCKWASHER, internal, #6
	211-0504-00			1	SCREW, 6-32 x 1/4 inch BHS
6	- - - - - -			1	CAPACITOR
	- - - - - -			-	mounting hardware: (not included w/capacitor)
	211-0503-00			1	SCREW, 6-32 x 3/16 inch BHS
	210-0202-00			2	LUG, solder, SE #6
	210-0935-00			2	WASHER, fiber, .140 ID x .375 inch OD
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
7	358-0166-00			2	BUSHING, black plastic
8	- - - - - -			1	TRANSFORMER
	- - - - - -			-	transformer includes:
	212-0515-00			4	SCREW, 10-32 x 2 1/4 inches HHS
	210-0812-00			4	WASHER, fiber, #10
	220-0410-00			4	NUT, keps, 10-32 x 3/8 inch
9	200-0260-00	100	786	1	COVER, capacitor, 2 1/32 inches
	200-0258-00	787		1	COVER, capacitor, 3 1/32 inches
10	- - - - - -			2	CAPACITOR
	- - - - - -			-	mounting hardware for each: (not included w/capacitor)
	214-0153-00			1	FASTENER, snap, double pronged
11	136-0007-00			1	SOCKET, STM7
	- - - - - -			-	mounting hardware: (not included w/socket)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
12	441-0599-00			1	CHASSIS, horizontal
	- - - - - -			-	mounting hardware: (not included w/chassis)
	212-0004-00			5	SCREW, 8-32 x 5/16 inch BHS
	212-0070-00			5	SCREW, 8-32 x 5/16 inch FHS phillips
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
13	426-0121-00			2	MOUNT, toroid
	- - - - - -			-	mounting hardware for each: (not included w/mount)
	361-0007-00			1	SPACER, nylon, .063 inch

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CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
14	210-201			13	LUG, solder, SE #4
	- - - -			-	mounting hardware for each: (not included w/lug)
	213-044			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
15	- - - -			1	CAPACITOR (see Ref #19)
	- - - -			-	capacitor includes:
16	200-293			1	COVER, capacitor
17	386-254			1	PLATE, fiber, large capacitor
18	432-048			1	BASE, large capacitor
19	- - - -			-	mounting hardware: (not included w/capacitor)
	211-516			2	SCREW, 6-32 x 7/8 inch BHS
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
20	136-022			1	SOCKET, STM9S
	- - - -			-	mounting hardware: (not included w/socket)
	213-044			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
21	210-204			2	LUG, solder, DE #6
	- - - -			-	mounting hardware for each: (not included w/lug)
	213-044			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
22	- - - -			2	CAPACITOR
	- - - -			-	each capacitor includes:
23	386-254			1	PLATE, fiber, large capacitor
	- - - -			-	mounting hardware for each: (not included w/capacitor)
	211-543			2	SCREW, 6-32 x 5/16 inch RHS
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
24	441-600			1	CHASSIS, vertical
	- - - -			-	mounting hardware: (not included w/chassis)
	212-004			5	SCREW, 8-32 x 5/16 inch BHS
	212-070			5	SCREW, 8-32 x 5/16 inch FHS phillips
	210-458			2	NUT, keps, 8-32 x 11/32 inch
25	- - - -			2	COIL
	- - - -			-	mounting hardware for each: (not included w/coil)
	213-054			1	SCREW, thread cutting, 6-32 x 5/16 inch PHS phillips
26	- - - -			1	COIL
	- - - -			-	mounting hardware: (not included w/coil)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
27	385-138			2	ROD, delrin, 1 5/8 inches
	- - - -			-	mounting hardware for each: (not included w/rod)
	211-507			1	SCREW, 6-32 x 5/16 inch BHS

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
28	136-0015-00			4	SOCKET, STM9G
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
29	131-0183-00			2	CONNECTOR, terminal feed-through
	- - - - - -			-	mounting hardware for each: (not included w/connector)
	358-0136-00			1	BUSHING, teflon
30	348-0056-00			1	GROMMET, plastic, 3/8 inch
31	- - - - - -			6	POT
	- - - - - -			-	mounting hardware for each: (not included w/pot)
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
32	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
	211-0544-00	100	619	1	SCREW, 6-32 x 3/4 inch THS phillips
	211-0553-00	620		1	SCREW, 6-32 x 1 1/2 inches RHS phillips
	210-0601-00	X620		1	EYELET, brass
	210-0478-00			1	NUT, hex, resistor mounting
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
33	348-0031-00			5	GROMMET, snap-in
34	- - - - - -			2	POT
	- - - - - -			-	mounting hardware for each: (not included w/pot)
	210-0046-00			1	LOCKWASHER, internal, .400 OD x .261 inch ID
	210-0940-00			1	WASHER, 1/4 ID x 3/8 inch OD
	210-0583-00			1	NUT, hex, 1/4-32 x 5/16 inch
35	200-0247-00			3	CAP, pot
36	- - - - - -			2	POT
	- - - - - -			-	mounting hardware for each: (not included w/pot)
	210-0207-00			1	LUG, solder, 3/8 inch
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
37	348-0055-00			1	GROMMET, plastic, 1/4 inch
38	200-0385-00	X150		1	COVER, transistor
39	136-0181-00	100	149	8	SOCKET, 3 pin transistor
	136-0182-00	150		8	SOCKET, 4 pin transistor
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	354-0234-00			1	RING, locking, transistor socket
40	136-0181-00	100	559	2	SOCKET, 3 pin transistor
	136-0182-00	560		2	SOCKET, 4 pin transistor
	- - - - - -			-	mounting hardware for each: (not included w/socket)
	354-0234-00			1	RING, locking, transistor socket

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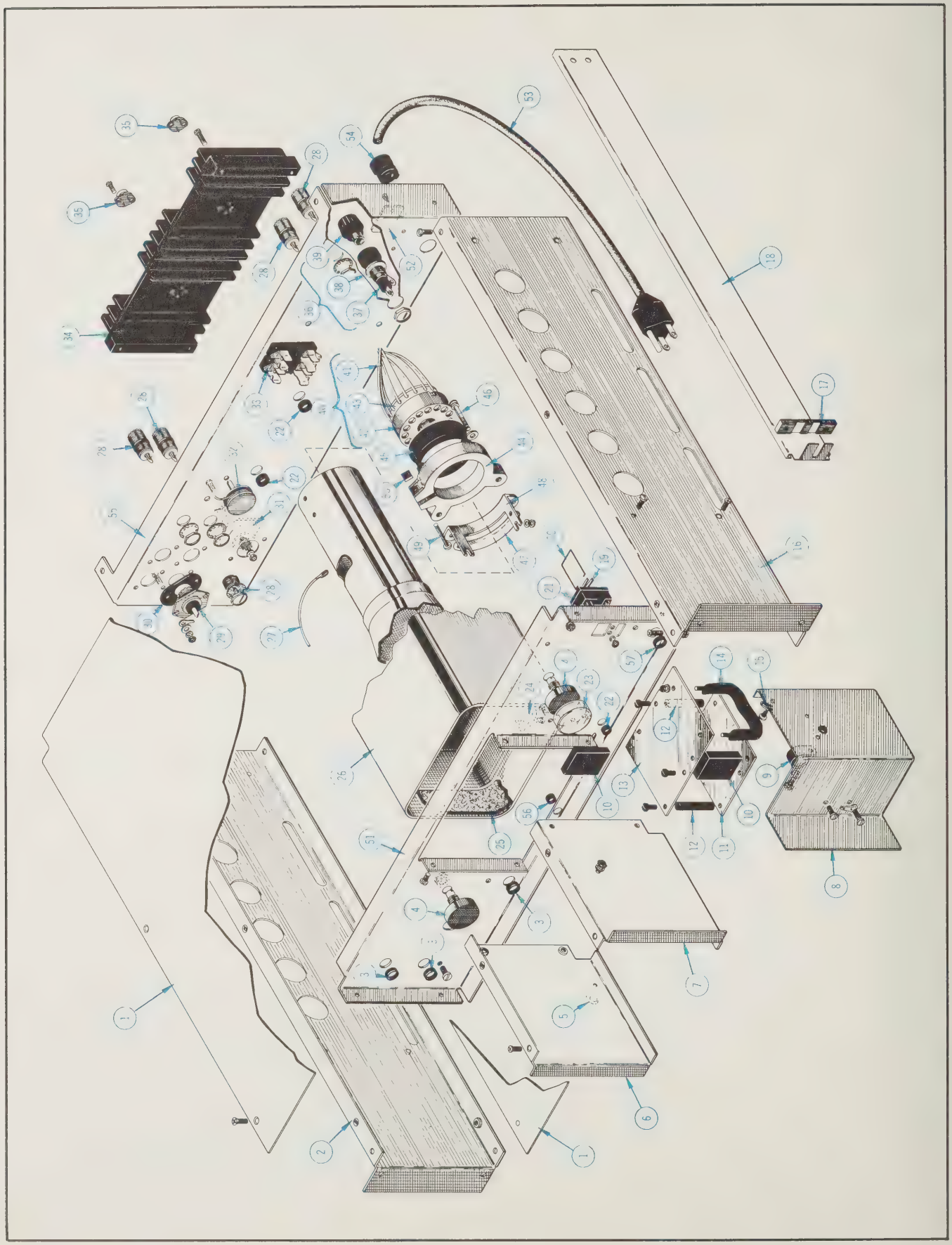
REAR



REAR

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	386-0108-00			2	PLATE, dust cover
	- - - - - -			-	mounting hardware for each: (not included w/plate)
	211-0504-00			6	SCREW, 6-32 x 1/4 inch BHS
2	386-0109-00			1	PLATE, left side
	- - - - - -			-	mounting hardware: (not included w/plate)
	212-0004-00			3	SCREW, 8-32 x 5/16 inch BHS
	212-0070-00			6	SCREW, 8-32 x 5/16 inch FHS phillips
	210-0458-00			9	NUT, keps, 8-32 x 11/32 inch
3	348-0063-00			3	GROMMET, plastic, 1/2 inch
4	- - - - - -			2	POT
	- - - - - -			-	mounting hardware for each: (not included w/pot)
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
5	343-0089-00			2	CLAMP, cable
6	407-0081-00			1	BRACKET, crt shield, left
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0538-00			2	SCREW, 6-32 x 5/16 inch FHS phillips
	212-0004-00			2	SCREW, 8-32 x 5/16 inch BHS
	212-0070-00			2	SCREW, 8-32 x 5/16 inch FHS phillips
	210-0458-00			2	NUT, keps, ,8-32 x 11/32 inch
7	407-0080-00			1	BRACKET, crt shield, right
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0538-00			2	SCREW, 6-32 x 5/16 inch FHS phillips
	212-0004-00			2	SCREW, 8-32 x 5/16 inch BHS
	212-0070-00			2	SCREW, 8-32 x 5/16 inch FHS phillips
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
8	407-0077-00			1	BRACKET, high voltage
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch BHS
9	343-0014-00			1	CLAMP, cable, 1 inch
	- - - - - -			-	mounting hardware: (not included w/clamp)
	211-0510-00			1	SCREW, 6-32 x 3/8 inch BHS
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
10	361-0083-00			2	SPACER, high voltage
	- - - - - -			-	mounting hardware for each: (not included w/spacer)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch BHS
11	392-0167-00			1	BOARD, focus & intensity
	- - - - - -			-	mounting hardware: (not included w/board)
	211-0558-00			6	SCREW, 6-32 x 1/4 inch BHS nylon

REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
12	385-0018-00			2	ROD, nylon
13	392-0166-00			1	BOARD, rectifier
	- - - - - -			-	mounting hardware: (not included w/board)
	211-0558-00			6	SCREW, 6-32 x 1/4 inch BH nylon
14	346-0001-00			1	STRAP, mounting, high voltage transformer
	- - - - - -			-	mounting hardware: (not included w/strap)
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
15	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: (not included w/lug)
	213-0044-00			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
16	386-0111-00			1	PLATE, right side
	- - - - - -			-	mounting hardware: (not included w/plate)
	212-0004-00			3	SCREW, 8-32 x 5/16 inch BHS
	212-0070-00			6	SCREW, 8-32 x 5/16 inch FHS phillips
	210-0458-00			9	NUT, keps, 8-32 x 11/32 inch
17	- - - - - -			2	SEE STANDARD ACCESSORIES
18	351-0040-00			1	SLIDE, chassis track, slide & guide, 1 pair (w/mounting hardware)
19	214-0538-00			1	SPRING, ground wire
20	214-0539-00			1	SPRING, retainer wire
21	136-0215-00			1	SOCKET, relay
	- - - - - -			-	mounting hardware: (not included w/socket)
	211-0008-00			1	SCREW, 4-40 x 1/4 inch BHS
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0406-00			1	NUT, hex, 4-40 x 3/16 inch
22	348-0056-00			4	GROMMET, plastic, 3/8 inch
23	200-0247-00			1	CAP, pot
24	352-0044-00			1	HOLDER, crt coil form
	- - - - - -			-	mounting hardware: (not included w/holder)
	211-0011-00			1	SCREW, 4-40 x 5/16 inch BHS
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0406-00			1	NUT, hex, 4-40 x 3/16 inch
25	124-0167-00			1	STRIP, crt shield
26	337-0725-00			1	SHIELD, crt
	- - - - - -			-	mounting hardware: (not included w/shield)
	211-0534-00			8	SCREW, 6-32 x 5/16 inch PHS w/lockwasher
	210-0803-00			8	WASHER, 6L x 3/8 inch
	210-0457-00			8	NUT, keps, 6-32 x 5/16 inch
27	175-0585-00			1	WIRE, crt lead, .290 foot, striped brown, w/connector
	175-0588-00	100	149X	1	WIRE, crt lead, .833 foot, striped orange, w/connector
	175-0592-00			1	WIRE, crt lead, .960 foot, striped green, w/connector
	175-0593-00			1	WIRE, crt lead, .333 foot, striped blue, w/connector
	175-0595-00			1	WIRE, crt lead, .960 foot, striped red, w/connector

©

REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
28	131-0081-00			5	CONNECTOR, coaxial, 1 contact, female, BNC
29	131-0064-00			4	CONNECTOR, coaxial
	- - - - - -			-	mounting hardware for each: (not included w/connector)
	211-0025-00			2	SCREW, 4-40 x 3/8 inch, FHS
	210-0224-00			1	LUG, solder, #10
	210-0812-00			2	WASHER, fiber, #10
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
30	406-0244-00			1	BRACKET, coaxial insulator
31	136-0089-00			1	SOCKET, 9 pin w/female insert
	- - - - - -			-	mounting hardware: (not included w/socket)
	211-0011-00			4	SCREW, 4-40 x 5/16 inch, BHS
	210-0004-00			3	LOCKWASHER, internal, #4
	210-0201-00			1	LUG, solder, SE #4
	210-0406-00			4	NUT, hex, 4-40 x 3/16 inch
32	214-0210-00			1	SPOOL, solder, assembly
	- - - - - -			-	spool assembly includes:
	214-0209-00			1	SPOOL, solder
	- - - - - -			-	mounting hardware: (not included w/spool)
	361-0007-00			1	SPACER, nylon, .063 inch
33	352-0025-00			1	HOLDER, fuse, dual
	- - - - - -			-	mounting hardware: (not included w/holder)
	211-0510-00			2	SCREW, 6-32 x 3/8 inch, BHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
34	214-0517-00			1	HEAT SINK
	- - - - - -			-	mounting hardware: (not included w/heat sink)
	212-0033-00			4	SCREW, 8-32 x 3/4 inch, BHS
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
35	- - - - - -			2	TRANSISTOR
	- - - - - -			-	mounting hardware for each: (not included w/transistor)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch, BHS
36	352-0002-00			1	HOLDER, fuse, assembly
	- - - - - -			-	holder assembly includes:
37	352-0010-00			1	HOLDER, fuse
38	210-0873-00			1	WASHER, rubber
	- - - - - -			1	NUT, fuse holder
39	200-0582-00			1	CAP, fuse
40	179-0954-00			1	CABLE HARNESS, crt, assembly
	- - - - - -			-	cable harness includes:
41	136-0216-00			1	SOCKET, crt, assembly
	- - - - - -			-	socket assembly includes:
42	136-0202-01	X150		1	SOCKET, crt
	- - - - - -			-	socket includes:
	214-0464-00			14	CONTACT, crt socket
43	200-0616-00	X150		1	COVER, crt socket

©

REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
44	354-0249-00			1	RING, crt clamping, assembly
	- - - - - -			-	ring includes:
45	124-0171-00			1	STRIP, liner, crt clamp
	- - - - - -			-	mounting hardware: (not included w/ring)
46	211-0576-00			2	SCREW, 6-32 x 7/8 inch, socket head cap
	210-0949-00			2	WASHER, 9/64 ID x 1/2 inch OD
47	214-0207-00			1	NUT, adjustment, securing
48	406-0730-00			1	BRACKET, adjustment
	- - - - - -			-	mounting hardware: (not included w/bracket)
	211-0534-00			4	SCREW, 6-32 x 5/16 inch, PHS w/lockwasher
	210-0803-00			4	WASHER, 6L x 3/8 inch
	210-0006-00			4	LOCKWASHER, internal, #6
	210-0407-00			4	NUT, hex, 6-32 x 1/4 inch
49	211-0560-00			1	SCREW, 6-32 x 1 inch, RHS
50	220-0419-00			1	NUT, square, 6-32 x 5/16 inch
51	386-0107-00			1	PLATE, bulkhead
52	334-0904-00			1	TAG, voltage rating
	- - - - - -			-	mounting hardware: (not included w/tag)
	213-0088-00			2	SCREW, thread forming, 4-40 x 1/4 inch, PHS phillips
53	161-0017-00			1	CORD, power
54	358-0025-00			1	BUSHING, strain relief
55	386-0110-00			1	PLATE, rear
56	348-0067-00	100	589	1	GROMMET, delrin, 5/16 inch
	358-0215-00	590		1	BUSHING, plastic, black
57	348-0063-00	100	786	1	GROMMET, delrin, 1/2 inch
	348-0064-00	787		1	GROMMET, delrin, 5/8 inch

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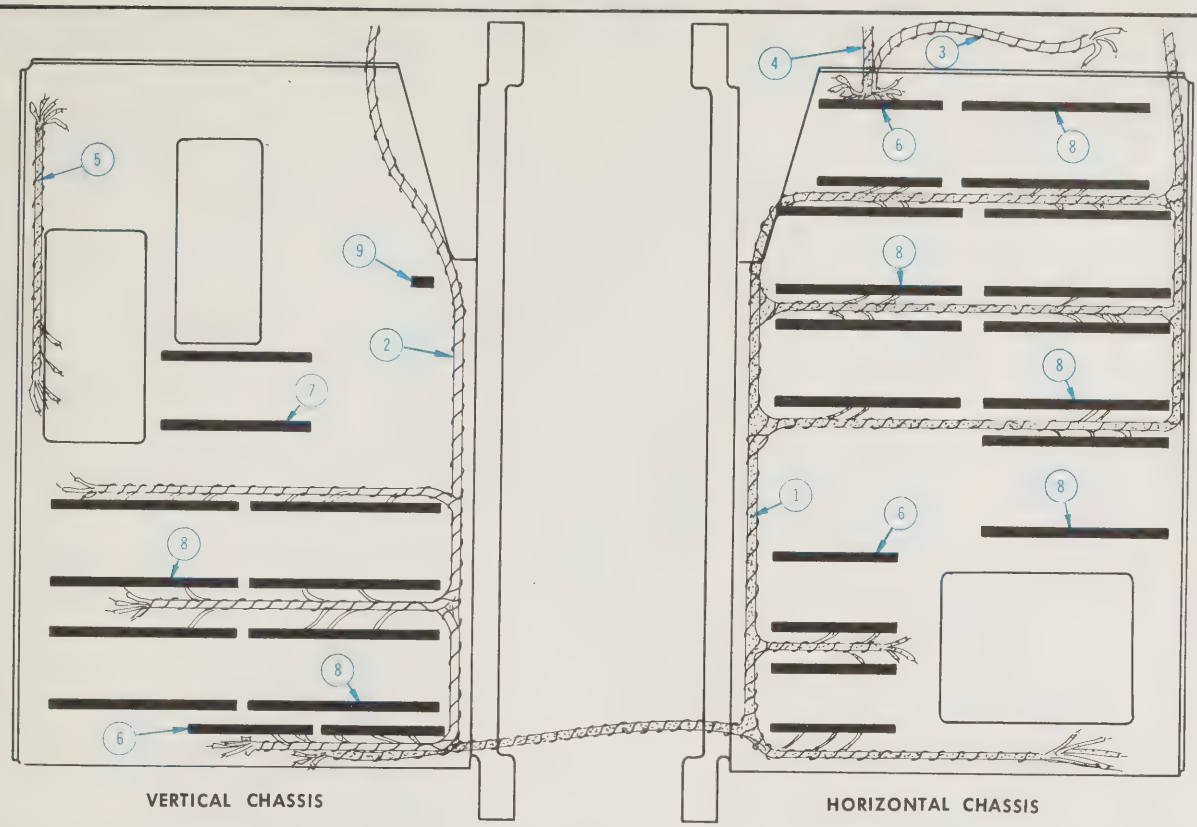
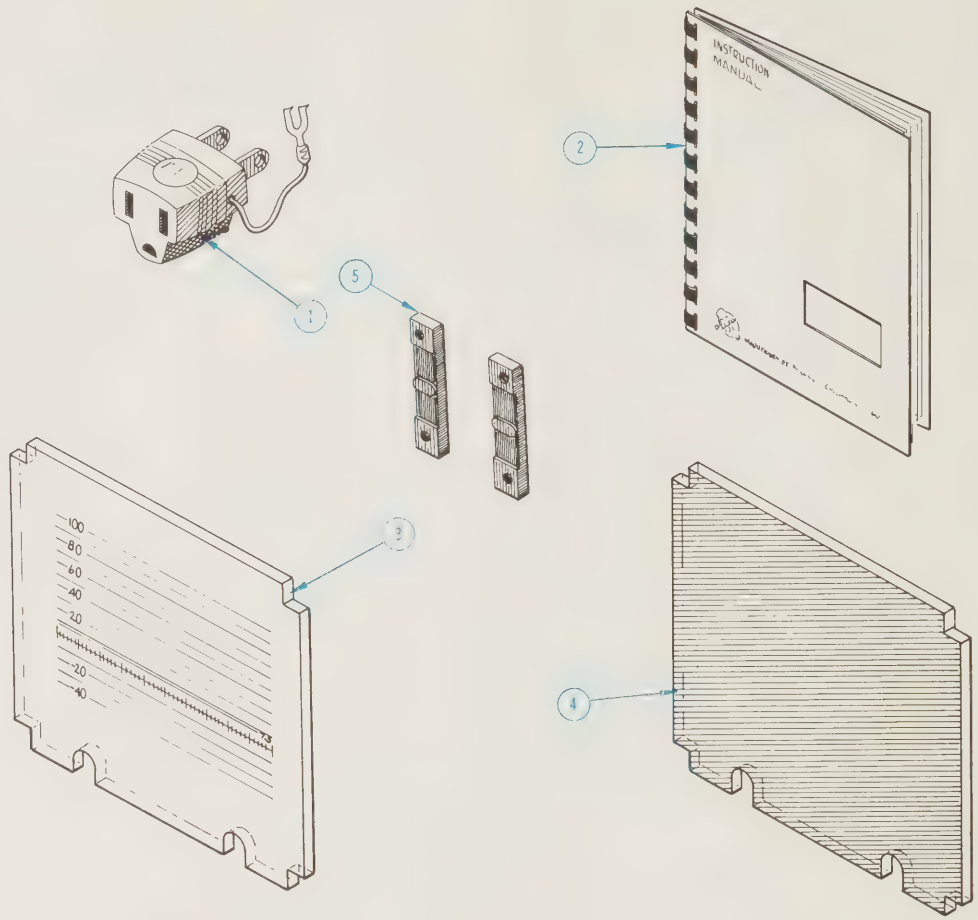
CABLE HARNESS & CERAMIC STRIP DETAIL



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	179-0950-00	100	786	1	CABLE HARNESS, horizontal
	179-0950-01	787		1	CABLE HARNESS, horizontal
2	179-0951-00	100	619	1	CABLE HARNESS, vertical
	179-0951-01	620		1	CABLE HARNESS, vertical
	- - - - - -			-	cable harness includes:
	175-0590-00	X150		1	WIRE, CRT lead, 1.937 feet, striped orange, w/connector
3	179-0953-00			1	CABLE HARNESS, high voltage
4	179-0956-00			1	CABLE HARNESS, focus & intensity
5	179-0952-00			1	CABLE HARNESS, switch
6	124-0147-00			8	STRIP, ceramic, 7/16 inch x 13 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, nylon, .313 inch
7	124-0146-00			2	STRIP, ceramic, 7/16 inch x 16 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, nylon, .313 inch
8	124-0145-00			20	STRIP, ceramic, 7/16 inch x 20 notches
	- - - - - -			-	each strip includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, nylon, .313 inch
9	124-0100-00	X620		1	STRIP, ceramic, 3/4 inch x 1 notch
					strip includes:
	355-0046-00			1	STUD, nylon
					mounting hardware: (not included w/strip)
	316-0007-00			1	SPACER, nylon, 1/16 inch

STANDARD ACCESSORIES



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	103-0013-00			1	ADAPTER, power cord
2	070-0466-00			2	MANUAL, instruction
3	331-0145-00	100	729	1	GRATICULE, composite standard, 140 IRE ruling
	331-0156-00	730	1568	1	GRATICULE, composite, 7 cm
	331-0156-01	1569		1	GRATICULE, composite, 7 cm
	331-0146-00	100	456	1	GRATICULE, 100 IRE ruling
	331-0157-00	457		1	GRATICULE, double scale
	331-0150-00	100	456	1	GRATICULE, combination composite
	331-0161-00	457		1	GRATICULE, plexiglas (installed)
	331-0077-01	X1569		1	GRATICULE, blank
4	378-0525-00			1	FILTER, light (installed)
5	381-0187-00	X1173		4	BAR, retainer

ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description					S/N Range
		Bulbs					
B242	150-030	Neon, NE-2V		CAL			
B604	150-001	Incandescent, #47		Graticule Light			
B605	150-001	Incandescent, #47		Graticule Light			
B864	150-030	Neon, NE-2V					
B865	150-030	Neon, NE-2V					
B866	150-030	Neon, NE-2V		POWER (ON)			
		Capacitors					
Tolerance ±20% unless otherwise indicated.							
C101	281-509	15 pf	Cer		500 v	10%	
C104	Use 285-623	0.47 μf	PTM		100 v		
C106	283-001	0.005 μf	Cer		500 v		
C113	Use 281-0604-00	2.2 pf	Cer		500 v	±0.25 pf	
C118B	281-061	5.5-18 pf	Cer	Var			
C118C	281-063	9-35 pf	Cer	Var			
C118D	Use 281-0509-00	15 pf	Cer		500 v	10%	
C122	283-004	0.02 μf	Cer		150 v		
C124	283-003	0.01 μf	Cer		150 v		
C130	283-0006-00	0.02 μf	Cer		500 v		X328-up
C133	281-060	2-8 pf	Cer	Var			
C134	Use 281-0629-00	33 pf (nominal value)		Selected			
C135	281-620	21 pf	Cer		500 v	1%	
C136	283-600	43 pf	Mica		500 v	5%	
C137	281-503	8 pf	Cer		500 v	±0.5 pf	
C138	281-594	150 pf	Cer		500 v	5%	
C139	283-594	0.001 μf	Mica		100 v	1%	
C144	281-558	18 pf	Cer		500 v		
C160	283-001	0.005 μf	Cer		500 v		
C163	283-000	0.001 μf	Cer		500 v		
C165	283-001	0.005 μf	Cer		500 v		
C198	290-217	250 μf	EMT		12 v		
C201	281-509	15 pf	Cer		500 v	10%	
C204	Use 285-623	0.47 μf	PTM		100 v		
C206	283-001	0.005 μf	Cer		500 v		
C213	Use 281-0604-00	2.2 pf	Cer		500 v	±0.25 pf	
C236	283-600	43 pf	Mica		500 v	5%	
C237	281-503	8 pf	Cer		500 v	±0.5 pf	
C244	281-558	18 pf	Cer		500 v		
C263	283-000	0.001 μf	Cer		500 v		
C265	283-001	0.005 μf	Cer		500 v		
C267	281-512	27 pf	Cer		500 v	10%	

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
C269	281-012	7-45 pf	Cer	Var			
C281	283-026	0.2 μf	Cer		25 v		
C285	281-518	47 pf	Cer		500 v		101-929
C285	281-0549-00	68 pf	Cer		500 v	10%	930-up
C286	281-518	47 pf	Cer		500 v		101-929
C286	281-0549-00	68 pf	Cer		500 v	10%	930-up
C292	283-001	0.005 μf	Cer		500 v		
C293	283-001	0.005 μf	Cer		500 v		
C294	281-523	100 pf	Cer		350 v		
C297	283-067	0.001 μf	Cer		200 v	10%	
C301	285-604	0.01 μf	PTM		400 v		
C304	283-104	0.002 μf	Cer		500 v		
C317	281-525	470 pf	Cer		500 v		
C327	281-521	56 pf	Cer		500 v	10%	
C335	281-623	650 pf	Cer		500 v		
C341	283-000	0.001 μf	Cer		500 v		
C342	283-001	0.005 μf	Cer		500 v		
C347	281-523	100 pf	Cer		350 v		
C351	281-513	27 pf	Cer		500 v		
C360	285-598	0.01 μf	PTM		100 v	5%	
C361	281-557	1.8 pf	Cer		500 v		
C364	283-596	528 pf	Mica		300 v	1%	
C370	281-546	330 pf	Cer		500 v	10%	
C371	283-081	0.1 μf	Cer		25 v		
C374	283-000	0.001 μf	Cer		500 v		
C375	283-000	0.001 μf	Cer		500 v		
C377	283-000	0.001 μf	Cer		500 v		
C379	283-000	0.001 μf	Cer		500 v		
C384	283-000	0.001 μf	Cer		500 v		
C385	283-000	0.001 μf	Cer		500 v		
C387	283-000	0.001 μf	Cer		500 v		
C410	283-000	0.001 μf	Cer		500 v		
C414	283-001	0.005 μf	Cer		500 v		
C417	285-633	0.22 μf	PTM		100 v	10%	
C420	281-536	0.001 μf	Cer		500 v	10%	
C424	283-001	0.005 μf	Cer		500 v		
C427	281-621	12 pf	Cer		500 v	1%	
C430	281-524	150 pf	Cer		500 v		
C436	281-525	470 pf	Cer		500 v		
C452	281-550	120 pf	Cer		500 v	10%	
C455	281-523	100 pf	Cer		350 v		
C461	283-081	0.1 μf	Cer		25 v		
C464	281-0551-00	390 pf	Cer		500 v	10%	X1719-up
C465	281-519	47 pf	Cer		500 v	10%	
C470	281-551	390 pf	Cer		500 v	10%	
C477	283-096	500 pf	Cer		20000 v		
C478	283-001	0.005 μf	Cer		500 v		
C481	281-012	7-45 pf	Cer	Var			

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Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
C482	283-519	360 pf	Mica		500 v	5%	
C483	285-595	0.1 μf	PTM		100 v	1%	
C484	283-000	0.001 μf	Cer		500 v		
C501	281-0616-00	6.8 pf	Cer		200 v		X787-up
C509	281-609	1 pf	Cer		200 v	10%	100-786
C509	281-0613-00	10 pf	Cer		200 v	10%	787-up
C517	283-000	0.001 μf	Cer		500 v		
C519	281-0558-00	18 pf	Cer		500 v		X1606-1718
C519	281-0504-00	10 pf	Cer		500 v	10%	1719-up
C521	281-010	4.5-25 pf	Cer	Var			100-1605
C521	281-0546-00	330 pf	Cer		500 v	10%	1606-1718X
C522	281-0518-00	47 pf	Cer		500 v		X1606-up
C523	281-0012-00	7-45 pf	Cer	Var			X1606-up
C553	283-0000-00	0.0001 μf	Cer		500 v		X1606-1718
C553	283-0003-00	0.01 μf	Cer		150 v		1719-up
C558	285-0627-00	0.0033 μf	PTM		100 V	5%	X1606-1718X
C575	283-081	0.1 μf	Cer		25 v		100-1605
C575	283-0026-00	0.2 μf	Cer		25 v		1606-1718
C575	283-0059-00	1 μf	Cer		25 v	+80%—20%	1719-up
C579	283-079	0.01 μf	Cer		250 v		X150-up
C610	290-0122-00	1000 μf	EMC		50 v		
C617	283-002	0.01 μf	Cer		500 v		
C620	290-145	10 μf	EMT		50 v		
C626	283-003	0.01 μf	Cer		150 v		
C640	290-0180-00	300 μf	EMC		250 v		
C644	283-079	0.01 μf	Cer		250 v		
C646	283-057	0.1 μf	Cer		200 v		
C649	290-149	5 μf	EMT		150 v		
C650	290-0179-00	125 μf	EMC		250 v		100-786
C650A,B	290-0059-00	160-10 μf	EMC		350 v		787-up
C800	290-213	10 μf	EMT		450 v		
C801	283-0111-00	0.1 μf	Cer		50 v		X1600-up
C804	283-004	0.02 μf	Cer		150 v		100-205X
C822	283-036	0.0025 μf	Cer		6000 v		
C832	281-556	500 pf	Cer		10000 v		
C834	283-006	0.02 μf	Cer		500 v		
C837	281-556	500 pf	Cer		10000 v		
C848	283-096	500 pf	Cer		20000 v		
C849	283-006	0.02 μf	Cer		500 v		
C850	281-0543-00	270 pf	Cer		500 v	10%	X1660-up
C875	281-0513-00	27 pf	Cer		500 v		X860-up
C876	283-032	470 pf	Cer		500 v	5%	

Diodes

Ckt. No.	Tektronix Part No.		Description	S/N Range
D109	*152-0185-00	Silicon	Replaceable by 1N3605	X1606-up
D209	*152-0185-00	Silicon	Replaceable by 1N3605	X1606-up
D271	*152-075	Germanium	Tek Spec	
D272	*152-075	Germanium	Tek Spec	
D282	*152-061	Silicon	Tek Spec	
D285	*152-185	Silicon	Replaceable by 1N3605	
D286	*152-185	Silicon	Replaceable by 1N3605	
D292	*152-185	Silicon	Replaceable by 1N3605	
D293	*152-185	Silicon	Replaceable by 1N3605	
D301	*152-185	Silicon	Replaceable by 1N3605	
D304	*152-185	Silicon	Replaceable by 1N3605	
D314	*152-185	Silicon	Replaceable by 1N3605	
D317	*152-185	Silicon	Replaceable by 1N3605	
D318	*152-185	Silicon	Replaceable by 1N3605	
D346	*152-185	Silicon	Replaceable by 1N3605	
D362	*152-185	Silicon	Replaceable by 1N3605	
D368	*152-185	Silicon	Replaceable by 1N3605	
D370	*152-185	Silicon	Replaceable by 1N3605	
D371	*152-185	Silicon	Replaceable by 1N3605	
D374	*152-185	Silicon	Replaceable by 1N3605	
D377	*152-185	Silicon	Replaceable by 1N3605	
D384	*152-185	Silicon	Replaceable by 1N3605	
D387	*152-185	Silicon	Replaceable by 1N3605	
D410	*152-185	Silicon	Replaceable by 1N3605	
D411	*152-185	Silicon	Replaceable by 1N3605	
D415	*152-185	Silicon	Replaceable by 1N3605	
D420	*152-185	Silicon	Replaceable by 1N3605	
D427	*152-185	Silicon	Replaceable by 1N3605	
D430	*152-185	Silicon	Replaceable by 1N3605	
D436	*152-185	Silicon	Replaceable by 1N3605	
D452	*152-185	Silicon	Replaceable by 1N3605	
D455	*152-185	Silicon	Replaceable by 1N3605	
D461	*152-075	Germanium	Tek Spec	
D464	*152-075	Germanium	Tek Spec	
D466	*152-185	Silicon	Replaceable by 1N3605	
D474	*152-061	Silicon	Tek Spec	
D475	*152-061	Silicon	Tek Spec	
D481	*152-185	Silicon	Replaceable by 1N3605	
D482	*152-185	Silicon	Replaceable by 1N3605	
D486	*152-185	Silicon	Replaceable by 1N3605	
D553	152-0142-00	Zener	1N972 0.4 w, 30 v, 10%	X1719-up
D556	*152-0185-00	Silicon	Replaceable by 1N3605	X1606-up
D571	*152-0185-00	Silicon	Replaceable by 1N3605	X1606-up
D610	152-066	1N3194		
D611	152-066	1N3194		

©

Diodes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
D614	152-123	Zener 1N935A 0.4 w, 9.1 v, 5%	
D640A,B,C,D	152-066	1N3194	
D650A,B,C,D	152-066	1N3194	
D881	*152-185	Silicon Replaceable by 1N3605	

Fuses

F601	159-041	1.25 Amp, 3AG, Slo-Blo, 115 v operation	
F601	159-043	0.6 Amp, 3AG, Slo-Blo, 230 v operation	
F637	159-031	0.4 Amp, 3AG, Slo-Blo	
F648	159-030	0.3 Amp, 3AG, Fast-Blo	

Relay

K385	148-024	4 PDT 24 v	

Inductors

L101	*108-326	150 nh		
L137	*108-109	60 μh		
L139	*108-214	400 μh		
L159	*108-260	0.1 μh		
L162	*114-182	58-90 μh	Var	Core 276-511 (2)
L201	*108-326	150 nh		
L237	*108-109	60 μh		
L239	*108-214	400 μh		
L259	*108-260	0.1 μh		
L262	*114-182	58-90 μh	Var	Core 276-511 (2)
L655	*108-285	CRT Beam Rotator		

Transistors

Q114	*151-108	Replaceable by 2N2501	
Q124†	*151-154	Replaceable by 2N2924	
Q144	*151-133	Selected from 2N3251	
Q154	*151-108	Replaceable by 2N2501	
Q164	*151-127	Selected from 2N2369	
Q174	Use 151-0063-00	2N2207	
Q184	Use 151-063	2N2207	
Q193	151-080	2N706	
Q214	*151-108	Replaceable by 2N2501	
Q244	*151-133	Selected from 2N3251	
Q254	*151-108	Replaceable by 2N2501	
Q264	*151-127	Selected from 2N2369	
Q273††	*151-153	Replaceable by 2N2923	
Q274	Use 151-063	2N2207	
Q280	151-107	2N967	

†151-155 may be substituted.

††151-154 and 151-155 may be substituted.

Transistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q284	Use 151-063	2N2207	
Q314	Use 151-063	2N2207	
Q325	Use 151-063	2N2207	
Q335	Use 151-063	2N2207	
Q344	151-041	2N1303	
Q355†††	*151-154	Replaceable by 2N2924	
Q365†††	*151-154	Replaceable by 2N2924	
Q375	151-041	2N1303	
Q385	151-041	2N1303	
Q405††	*151-153	Replaceable by 2N2923	
Q414	*151-151	Replaceable by 2N930	
Q415	*151-151	Replaceable by 2N930	
Q420	151-071	2N1305	
Q455††††	*151-155	Replaceable by 2N2925	
Q465†††	*151-154	Replaceable by 2N2924	
Q474	*151-096	Selected from 2N1893	
Q481	Use *151-0103-00	Replaceable by 2N2219	
Q483	*151-155	Replaceable by 2N2925	
Q533	Use 151-0063-00	2N2207	100-1605
Q533	*151-0133-00	Selected from 2N3251	1606-up
Q544	Use 151-063	2N2207	100-1605
Q544	*151-0151-00	Replaceable by 2N930	1606-up
Q574	Use 151-063	2N2207	
Q616	*151-151	Replaceable by 2N930	
Q626	*151-151	Replaceable by 2N930	
Q634††	*151-153	Replaceable by 2N2923	
Q637	151-137	2N2148	
Q643†	*151-155	Replaceable by 2N2925	
Q644	*151-134	Replaceable by 2N2905	
Q647	*151-148	RCA 40250 Selected	
Q804	*151-136	Replaceable by 2N3053	
Q874	151-040	2N1302	860-up
Q874	Use *151-0103-00	Replaceable by 2N2219	100-859

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R101	315-100	10 Ω	¼ w		5%
R104	Use 319-031	1 meg	¼ w	Prec	1%
R106	316-474	470 k	¼ w		
R110	316-101	100 Ω	¼ w		
R113	316-272	2.7 k	¼ w		100-1599

†151-155 may be substituted.

††151-154 and 151-155 may be substituted.

†††151-153 and 151-155 may be substituted.

††††151-154 may be substituted.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
	315-0682-00	6.8 k	1/4 w			5%	1600-up
R114	321-227	2.26 k	1/8 w		Prec	1%	
R115	311-310	5 k		Var		DC BAL	100-1599
R115	311-0546-00	10 k		Var		DC BAL	1600-up
R118A	321-247	3.65 k	1/8 w		Prec	1%	
R118B	321-219	1.87 k	1/8 w		Prec	1%	
R118C	321-167	536 Ω	1/8 w		Prec	1%	
R119	311-169	100 Ω		Var		X5 MAG GAIN	
R120	321-175	649 Ω	1/8 w		Prec	1%	
R121	308-212	10 k	3 w		WW	5%	100-1599
R121	308-0334-00	7 k	3 w		WW	3%	1600-up
R122	321-271	6.49 k	1/8 w		Prec	1%	
R123	321-253	4.22 k	1/8 w		Prec	1%	100-1599
R123	321-0250-00	3.92 k	1/8 w		Prec	1%	1600-up
R130	311-224	50 k		Var		VAR DC BAL	
R131	316-273	27 k	1/4 w				100-327
R131	315-0823-00	82 k	1/4 w			5%	328-up
R135	321-279	7.87 k	1/8 w		Prec	1%	
R141	321-131	226 Ω	1/8 w		Prec	1%	
R143	305-153	15 k	2 w			5%	
R144	321-297	12.1 k	1/8 w		Prec	1%	
R148	301-333	33 k	1/2 w			5%	
R149	316-392	3.9 k	1/4 w				
R154	321-213	1.62 k	1/8 w		Prec	1%	
R160	308-107	1 k	5 w		WW	5%	100-619
R160	308-0017-00	2 k	10 w		WW	5%	620-up
R162	*310-621	3 k	8 w		Prec	1%	
R163	316-104	100 k	1/4 w				
R164	316-470	47 Ω	1/4 w				
R166	308-077	1 k	3 w		WW		
R168	315-910	91 Ω	1/4 w			5%	100-929
R168	315-0750-00	75 Ω	1/4 w			5%	930-up
R169	311-003	100 Ω		Var		VERT GAIN	
R172	315-112	1.1 k	1/4 w			5%	
R173	304-273	27 k	2 w				
R183	316-271	270 Ω	1/4 w				
R184	316-103	10 k	1/4 w				
R192	316-222	2.2 k	1/4 w				
R193	316-122	1.2 k	1/4 w				
R198	301-750	75 Ω	1/2 w			5%	
R199	316-103	10 k	1/4 w				
R201	315-100	10 Ω	1/4 w			5%	
R204	Use 319-031	1 meg	1/4 w		Prec	1%	
R206	316-474	470 k	1/4 w				
R210	316-101	100 Ω	1/4 w				

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R213	316-272	2.7 k	1/4 w				100-1599
R213	315-0682-00	6.8 k	1/4 w			5%	1600-up
R214	321-227	2.26 k	1/8 w		Prec	1%	
R220	321-175	649 Ω	1/8 w		Prec	1%	
R231	316-273	27 k	1/4 w				100-327
R231	315-0823-00	82 k	1/4 w			5%	328-up
R240†	311-506	500 Ω		Var		VARIABLE (MAG)	
R241	321-121	178 Ω	1/8 w		Prec	1%	
R242	316-224	220 k	1/4 w				
R243	305-153	15 k	2 w			5%	
R244	321-297	12.1 k	1/8 w		Prec	1%	
R245	311-016	10 k		Var		POSITION (VERT)	
R248	301-333	33 k	1/2 w			5%	
R249	316-392	3.9 k	1/4 w				
R254	321-213	1.62 k	1/8 w		Prec	1%	
R262	*310-621	3 k	8 w		Prec	1%	
R263	316-104	100 k	1/4 w				
R264	316-470	47 Ω	1/4 w				
R266	308-077	1 k	3 w		WW		
R267	316-271	270 Ω	1/4 w				
R268	315-910	91 Ω	1/4 w			5%	100-929
R268	315-0750-00	75 Ω	1/4 w			5%	930-up
R274	315-153	15 k	1/4 w			5%	
R275	315-752	7.5 k	1/4 w			5%	
R276	316-104	100 k	1/4 w				
R280	316-183	18 k	1/4 w				
R281	316-682	6.8 k	1/4 w				
R282	316-105	1 meg	1/4 w				
R283	316-151	150 Ω	1/4 w				
R284	316-150	15 Ω	1/4 w				
R285	315-104	100 k	1/4 w			5%	
R286	315-104	100 k	1/4 w			5%	
R287	315-273	27 k	1/4 w			5%	
R288	315-273	27 k	1/4 w			5%	
R289	316-333	33 k	1/4 w				
R290	315-472	4.7 k	1/4 w			5%	
R292	315-224	220 k	1/4 w			5%	
R293	315-224	220 k	1/4 w			5%	
R296	316-101	100 Ω	1/4 w				
R297	316-103	10 k	1/4 w				
R298	315-472	4.7 k	1/4 w			5%	
R299	315-104	100 k	1/4 w			5%	
R301	301-564	560 k	1/2 w			5%	
R304	315-155	1.5 meg	1/4 w			5%	
R305	316-103	10 k	1/4 w				

†Furnished as a unit with SW240.

©

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R310	316-101	100 Ω	1/4 w			
R313	316-153	15 k	1/4 w			
R314	316-153	15 k	1/4 w			
R315	316-223	22 k	1/4 w			
R316	316-103	10 k	1/4 w			100-127X
R317	316-106	10 meg	1/4 w			
R318	316-106	10 meg	1/4 w			
R319	316-226	22 meg	1/4 w			100-127
R319	316-335	3.3 meg	1/4 w			128-up
R321	316-224	220 k	1/4 w			100-127X
R323	301-393	39 k	1/2 w		5%	
R324	321-218	1.82 k	1/8 w	Prec	1%	
R325	311-369	100 k		Var	TRIG MULTI BIAS	
R326	301-393	39 k	1/2 w		5%	
R327	315-123	12 k	1/4 w		5%	
R333	301-393	39 k	1/2 w		5%	
R334	302-182	1.8 k	1/2 w			
R335	321-201	1.21 k	1/8 w	Prec	1%	
R341	301-682	6.8 k	1/2 w		5%	
R342	301-272	2.7 k	1/2 w		5%	
R343	315-183	18 k	1/4 w		5%	
R344	302-392	3.9 k	1/2 w			
R346	316-226	22 meg	1/4 w			
R347	315-103	10 k	1/4 w		5%	
R351	315-103	10 k	1/4 w		5%	
R354	315-683	68 k	1/4 w		5%	
R355	315-103	10 k	1/4 w		5%	
R358	315-243	24 k	1/4 w		5%	
R360	311-183	500 k		Var	EVEN FIELD SYNC	
R361	316-474	470 k	1/4 w			
R364	315-683	68 k	1/4 w		5%	
R365	315-103	10 k	1/4 w		5%	
R368	315-155	1.5 meg	1/4 w		5%	
R369	316-103	10 k	1/4 w			
R371	316-336	33 meg	1/4 w			
R372	Use 316-472	4.7 k	1/4 w			
R374	315-103	10 k	1/4 w		5%	
R375	316-473	47 k	1/4 w			
R376	316-182	1.8 k	1/4 w			
R377	316-473	47 k	1/4 w			
R378	316-105	1 meg	1/4 w			
R379	316-102	1 k	1/4 w			
R384	315-103	10 k	1/4 w		5%	
R385	316-473	47 k	1/4 w			
R386	316-182	1.8 k	1/4 w			

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R387	316-473	47 k	¼ w			
R388	316-105	1 meg	¼ w			
R389	316-104	100 k	¼ w			
R404	315-154	150 k	¼ w		5%	
R405	315-123	12 k	¼ w		5%	
R406	315-154	150 k	¼ w		5%	
R410	316-105	1 meg	¼ w			
R414	Use 323-352	45.3 k	½ w	Prec	1%	
R415	323-302	13.7 k	½ w	Prec	1%	
R417	321-452	499 k	⅛ w	Prec	1%	
R419	315-472	4.7 k	¼ w		5%	
R420	316-471	470 Ω	¼ w			
R424	316-823	82 k	¼ w			
R427	315-472	4.7 k	¼ w		5%	
R428	323-308	15.8 k	½ w	Prec	1%	
R429	311-360	5 k	Var		DELAY	
R430	316-103	10 k	¼ w			
R431	316-104	100 k	¼ w			
R436	316-102	1 k	¼ w			
R437	316-104	100 k	¼ w			
R438	316-393	39 k	¼ w			
R450	315-104	100 k	¼ w		5%	
R451	315-223	22 k	¼ w		5%	
R452	315-223	22 k	¼ w		5%	
R453	303-303	30 k	1 w		5%	
R454	315-623	62 k	¼ w		5%	
R455	315-472	4.7 k	¼ w		5%	
R456	323-320	21 k	½ w	Prec	1%	
R461	316-333	33 k	¼ w			
R464	301-433	43 k	½ w		5%	
R465	315-113	11 k	¼ w		5%	
R466	321-335	30.1 k	⅛ w	Prec	1%	
R468	301-154	150 k	½ w		5%	
R469	301-473	47 k	½ w		5%	
R470	315-113	11 k	¼ w		5%	
R471	316-563	56 k	¼ w			
R474	*310-614	41.5 k	8 w	Prec	1%	
R475	316-105	1 meg	¼ w			
R476	316-393	39 k	¼ w			
R477	302-273	27 k	½ w			
R478	316-103	10 k	¼ w			
R481	321-409	178 k	⅛ w	Prec	1%	
R482	321-350	43.2 k	⅛ w	Prec	1%	
R483	321-397	133 k	⅛ w	Prec	1%	
R484	321-379	86.6 k	⅛ w	Prec	1%	

©

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R486	316-475	4.7 meg	1/4 w				100-1718
R486	316-0334-00	330 k	1/4 w			10%	1719-up
R487	316-224	220 k	1/4 w				
R488	316-103	10 k	1/4 w				
R489	304-183	18 k	1 w				
R491	301-752	7.5 k	1/2 w			5%	
R492	321-329	26.1 k	1/8 w		Prec	1%	
R501	323-498	1.5 meg	1/2 w		Prec	1%	100-786
R501	323-0496-00	1.43 meg	1/2 w		Prec	1%	787-up
R502	321-440	374 k	1/8 w		Prec	1%	100-786
R502	321-0450-00	475 k	1/8 w		Prec	1%	787-up
R504	323-481	1 meg	1/2 w		Prec	1%	100-786
R504	323-0468-00	732 k	1/2 w		Prec	1%	787-up
R509	323-481	1 meg	1/2 w		Prec	1%	
R510	316-101	100 Ω	1/4 w				
R514	302-223	22 k	1/2 w				
R516	321-368	66.5 k	1/8 w		Prec	1%	
R517	321-339	33.2 k	1/8 w		Prec	1%	100-786
R517	321-0351-00	44.2 k	1/8 w		Prec	1%	787-up
R520	323-377	82.5 k	1/2 w		Prec	1%	
R521	321-249	3.83 k	1/4 w		Prec	1%	
R522	321-318	20 k	1/8 w		Prec	1%	100-1605
R522	321-0317-00	19.6 k	1/8 w		Prec	1%	1606-up
R523	321-389	110 k	1/8 w		Prec	1%	100-1605
R523	321-0386-00	102 k	1/8 w		Prec	1%	1606-up
R525	323-373	75 k	1/2 w		Prec	1%	
R533	316-224	220 k	1/4 w				
R534	315-222	2.2 k	1/4 w			5%	
R535	315-273	27 k	1/4 w			5%	
R544	315-393	39 k	1/4 w			5%	100-1605
R544	316-0274-00	270 k	1/4 w				1606-up
R551	316-101	100 Ω	1/4 w				
R552	315-0104-00	100 k	1/4 w			5%	X1606-up
R553	315-0474-00	470 k	1/4 w			5%	X1606-1718
R553	316-0102-00	1 k	1/4 w				1719-up
R554	*310-614	41.5 k	8 w		Prec	1%	
R556	315-682	6.8 k	1/4 w			5%	100-1605
R556	321-0269-00	6.19 k	1/8 w		Prec		1606-up
R558	Use 322-0123-00	187 Ω	1/4 w		Prec	1%	
R561	316-101	100 Ω	1/4 w				
R564	*310-614	41.5 k	8 w		Prec	1%	
R566	315-682	6.8 k	1/4 w			5%	100-1605
R566	321-0269-00	6.19 k	1/8 w		Prec	1%	1606-up
R568	311-178	200 Ω		Var		HORIZ GAIN	
R571	316-0473-00	47 k	1/4 w				X1606-up

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
R574	315-393	39 k	1/4 w		5%	100-1605
R574	316-0273-00	27 k	1/4 w			1606-up
R575	311-178	200 Ω		Var	SWP/MAG REGIS	
R576	316-0392-00	3.9 k	1/4 w			X1606-up
R579	311-360	5 k		Var	POSITION (HORIZ)	
R605	311-377	25 Ω		Var WW	SCALE ILLUM	
R614	315-242	2.4 k	1/4 w		5%	
R616	315-184	180 k	1/4 w		5%	
R617	316-471	470 Ω	1/4 w			
R618	315-183	18 k	1/4 w		5%	
R620	311-147	10 k		Var	—25 VOLTS CAL AMPL	
R621	302-122	1.2 k	1/2 w			
R624	321-206	1.37 k	1/8 w	Prec	1%	
R625	315-103	10 k	1/4 w		5%	
R626	321-233	2.61 k	1/8 w	Prec	1%	
R634	304-223	22 k	1 w			
R640	307-007	2.7 Ω	1 w			
R641	323-335	30.1 k	1/2 w	Prec	1%	
R642	321-277	7.5 k	1/8 w	Prec	1%	
R643	316-104	100 k	1/4 w			
R644	316-102	1 k	1/4 w			
R645	302-0103-00	10 k	1/2 w			X787-up
R646	316-221	220 Ω	1/4 w			
R647	304-120	12 Ω	1 w			
R648	302-103	10 k	1/2 w			
R650	307-009	4.7 Ω	1 w			
R652	302-0102-00	1 k	1/2 w			X787-up
R655	311-317	2 x 1 k		Var	CRT BEAM ROTATOR	
R800	302-101	100 Ω	1/2 w			
R801	302-0100-00	10 Ω	1/2 w			X1600-up
R802	316-101	100 Ω	1/4 w			
R809	316-105	1 meg	1/4 w			
R810	316-101	100 Ω	1/4 w			
R814	311-184	1 meg		Var	VERTICAL GAIN	
R815	316-335	3.3 meg	1/4 w			
R834	316-684	680 k	1/4 w			
R835	311-183	500 k		Var	HIGH VOLTAGE	
R837	305-565	5.6 meg	2 w		5%	
R838	305-685	6.8 meg	2 w		5%	
R839	305-565	5.6 meg	2 w		5%	
R841	305-685	6.8 meg	2 w		5%	
R842	305-565	5.6 meg	2 w		5%	
R843	305-685	6.8 meg	2 w		5%	
R844	311-505	10 meg		Var	FOCUS	
R845	305-685	6.8 meg	2 w		5%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R846	311-043	2 meg		Var	INTENSITY	
R847	315-184	180 k	1/4 w		5%	
R848	315-155	1.5 meg	1/4 w		5%	
R849	302-155	1.5 meg	1/2 w			
R864	311-184	1 meg		Var	ASTIG	
R865	316-334	330 k	1/4 w			100-149
R865	302-824	820 k	1/2 w			150-619X
R866	316-336	33 meg	1/4 w			100-149
R866	302-684	680 k	1/2 w			150-up
R867	316-0184-00	180 k	1/4 w			X620-up
R874	304-273	27 k	1 w			
R875	316-393	39 k	1/4 w			
R876	316-471	470 Ω	1/4 w			100-859
R876	316-0152-00	1.5 k	1/4 w			860-up
R881	321-327	24.9 k	1/8 w	Prec	1%	
R882	321-146	324 Ω	1/8 w	Prec	1%	
R883	321-191	953 Ω	1/8 w	Prec	1%	
R885	321-141	287 Ω	1/8 w	Prec	1%	
R886	321-179	715 Ω	1/8 w	Prec	1%	

Switches

	Unwired	Wired			S/N Range
SW101	260-658	*262-685	Rotary	VERTICAL INPUT	
SW118	260-654	*262-687	Rotary	VOLTS FULL SCALE	
SW135	260-655 Use	*262-0686-01	Rotary	VERTICAL RESPONSE	
SW240†	311-506				
SW290	260-473		Lever	DC RESTORER	
SW305	260-473		Lever	SYNC	
SW380	260-473		Lever	FIELD SHIFT	
SW430	260-657	*262-688	Rotary	HORIZONTAL DISPLAY	
SW520	260-656	*262-689	Rotary	HORIZONTAL MAG	100-1605
SW520	260-0656-00	*262-0689-00	Rotary	HORIZONTAL MAG	1606-1718
SW520	260-0656-00	*262-0689-02	Rotary	HORIZONTAL MAG	1719-up
SW601	260-199		Toggle	POWER	
SW885	260-490		Lever	CALIBRATOR	

Transformers

T135	120-362	RF 3.58 MC	Center frequency
T280	*120-365	Toroid	4 windings
T420	*120-366	Toroid	2 windings
T601	*120-363	Power	
T801	*120-364	High Voltage	

†Furnished as a unit with R240.

Electron Tubes

Ckt. No.	Tektronix Part No.	Description	S/N Range
V113	154-039	12AT7	
V164	154-420	7788	
V264	154-420	7788	
V293	154-039	12AT7	
V514	154-022	6AU6	
V554	154-187	6DJ8	
V800	154-468	6GV8	
V822	154-051	5642	
V832	154-051	5642	
V859	*154-473	T5290-31 Crt Standard Phosphor	

Electron Tubes

Ckt. No.	Tektronix Part No.	Description	S/N Range
V113	154-039	12AT7	
V164	154-420	7788	
V264	154-420	7788	
V293	154-039	12AT7	
V514	154-022	6AU6	
V554	154-187	6DJ8	
V800	154-468	6GV8	
V822	154-051	5642	
V832	154-051	5642	
V859	*154-473	T5290-31 Crt Standard Phosphor	

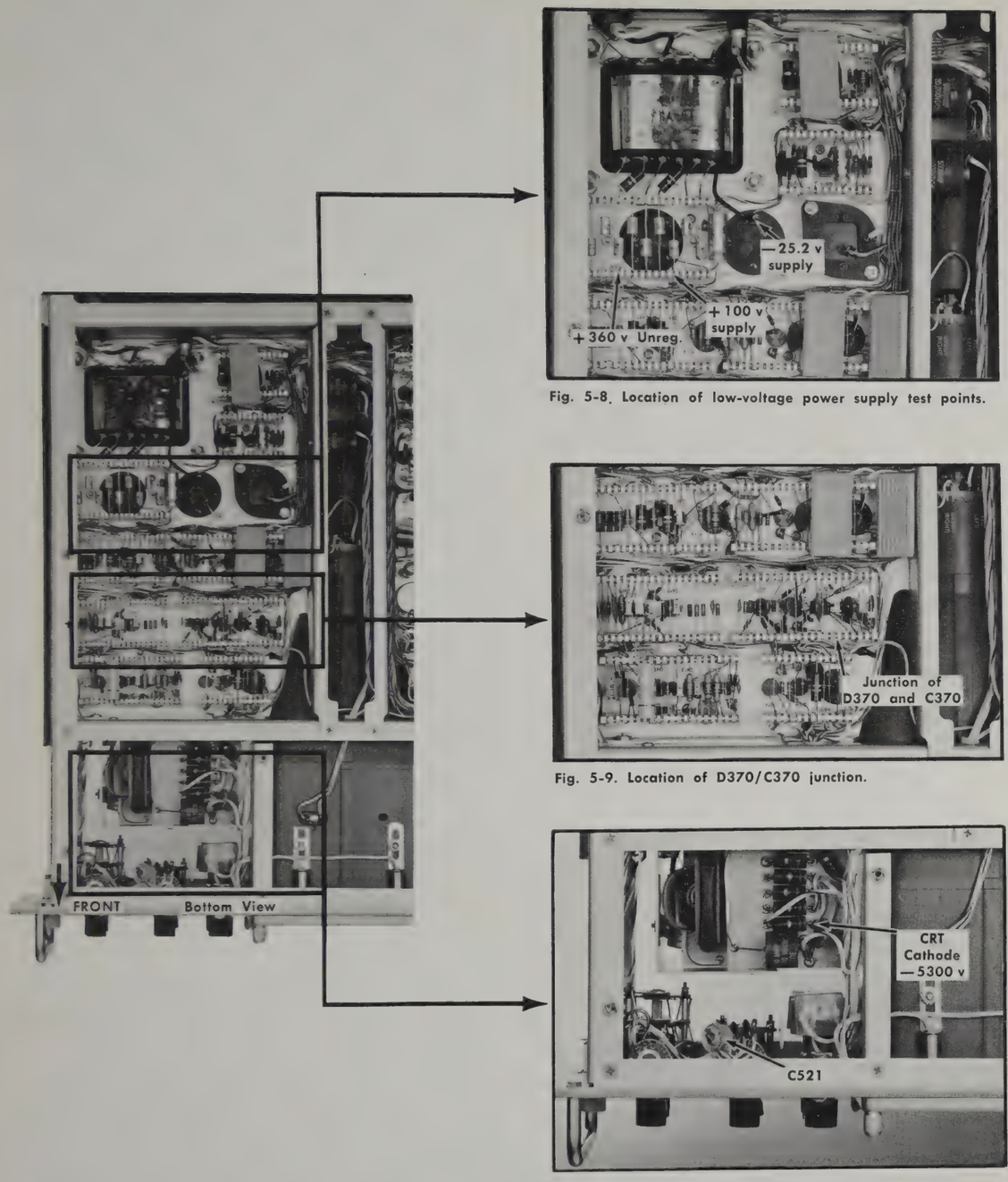


Fig. 5-8. Location of low-voltage power supply test points.

Fig. 5-9. Location of D370/C370 junction.

Fig. 5-10. Location of high-voltage test point and adjustment C521.

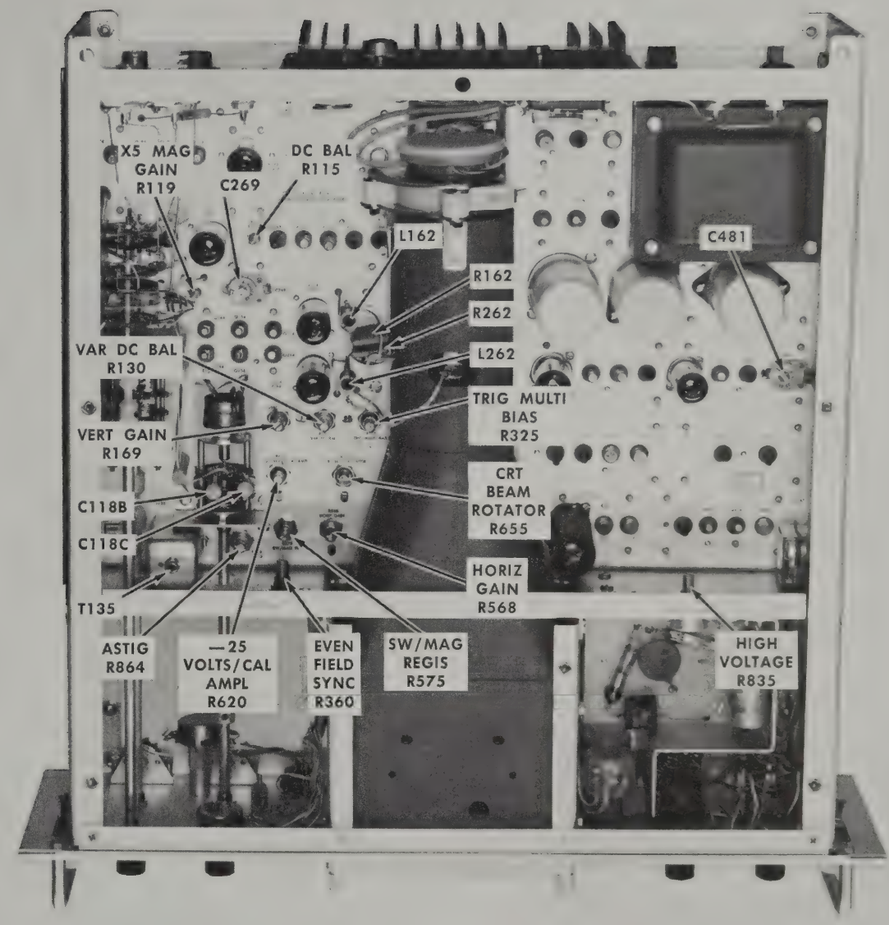
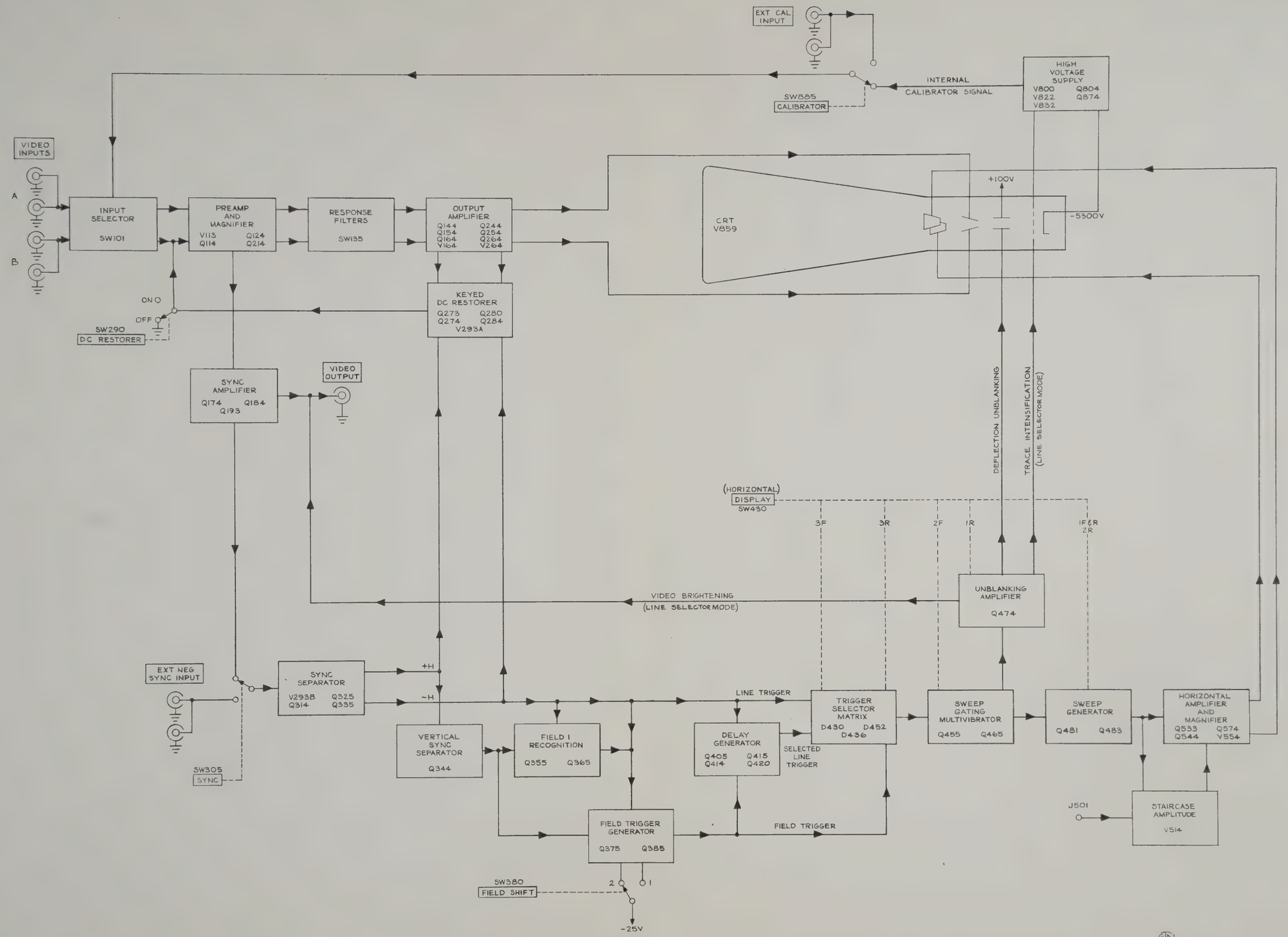


Fig. 5-11. Location of internal adjustments (top view).

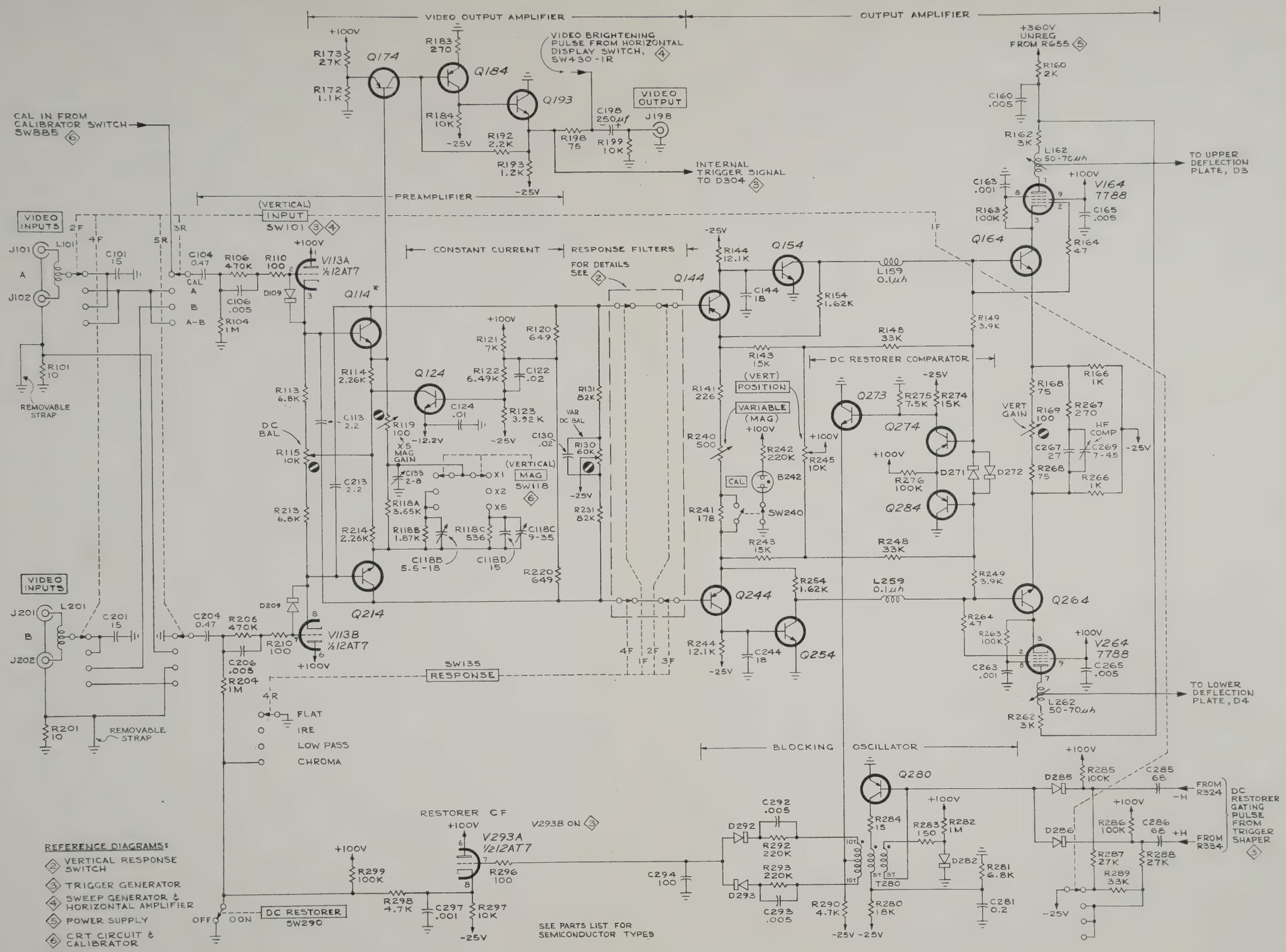


GN 366

TYPE RM529 WAVEFORM MONITOR

G

BLOCK DIAGRAM



MRH
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VERTICAL AMPLIFIER AND DC RESTORER

IMPORTANT

VOLTAGE AND WAVEFORM CONDITIONS

Circuit voltages measured with a 20,000 Ω/volt VOM. All readings in volts. Voltages are measured with respect to chassis ground unless otherwise noted.

Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule.

Voltages and waveforms on the schematics (shown in blue) are not absolute and may vary between instruments.

The test oscilloscope used had the following characteristics: Minimum deflection factor, 0.02 volts/division using a 10X probe; frequency response, dc to 30 MHz; sweep rates, 5 ms to 20 μs; sweep magnification, X1, X20 and X100. AC input coupling was used.

To indicate true time relationship between signals and to obtain stable displays, the test oscilloscope was externally triggered through X1 probe form:

1. Collector of Q325 (-H signal) for all waveforms except those at the junctions of C198 and R198, C364 and R365, C417 and the Collector of Q415.

2. Collector of Q344 for waveforms at the junctions of C198 and R198, C364 and R365, C417 and the collector of Q415.

Voltage readings and waveforms were obtained using the following control settings, unless otherwise noted on the individual diagrams.

For waveforms, 1-volt of modulated staircase was connected to the left VIDEO INPUTS A connector. The right VIDEO INPUTS A connector was terminated into 75 ohms.

For voltage readings, no input signal or termination was connected to the instrument.

POWER and SCALE ILLUM	2/3 clockwise
FOCUS	Midrange
INTENSITY	Adjusted for normal display brightness
GAIN	As is
VERTICAL Controls	
RESPONSE	FLAT
DC RESTORER	ON
INPUT	A
VOLTS FULL SCALE	1.0
VARIABLE (VOLTS FULL SCALE)	CALIB
CAL	.714 F.S.
POSITION	Midrange
HORIZ Controls	
POSITION	Midrange
SYNC	INT
MAG	X1
DISPLAY	LINE SELECTOR .25 H/cm
LINE SELECTOR (SWITCH)	Variable
FIELD	TWO
VARIABLE (LINE SELECTOR)	Fully clockwise

+TYPE RM529 WAVEFORM MONITOR

VERTICAL AMPLIFIER ◇1

S/N 2997 - UP

S/N 3666

CAL IN FROM CALIBRATOR SWITCH SW 485 ◇10

SW101 INPUT (VERTICAL) ◇3 ◇4

2F 4F 5R 3R

(ON REAR PANEL) VIDEO INPUT

J101 A J102 L101 150nH

C101 15

CAL A B A-B

C104 0.47 C106 .005

R106 470K R110 100

R104 1M

D109

R101 10

REMOVABLE STRAP

+100V

V113A ½12AT7

+1.04

R113 6.8K

C113 2.2

R115 10K DC BAL

C213 2.2

R213 6.8K

R119 100 0.2 VOLTS GAIN

R214 2.26K

0.2V/DIV 20µS/DIV

+0.39

Q114

SW118 VOLTS FULL SCALE

C118B (5.5-18) C118D /27 R118C 536 C118C 9-35

R118B 1.87K R118A 3.65K 1.0 0.5 0.2

R114 2.26K

C119 2-8

-5.5

Q124

C124 .01

-12.5V

R123 3.92K

-25V

+100V

R121 7K

+10.25

R122 6.49K C122 .02

C130 .02

VAR DC BAL R130 50K

R120 649

R131 82K

R231 82K

R220 649

+8.25

Q214

+0.95

D209

R206 470K R210 100

C204 0.47 C206 .005

R204 1M

V113B ½12AT7

+100V

0.1V/DIV 20µS/DIV

+8.25

SW135 RESPONSE

4R FLAT IEEE LOW PASS HIGH PASS

1F 3F 4F 2F

(ON REAR PANEL) VIDEO INPUT

J201 B J202 L201 150nH

C201 15

R201 10

REMOVABLE STRAP

ON OFF SW290 DC RESTORER

FROM R298 ◇3

Q174 -0.78 Q184 Q193

R173 27K R172 1.1K

R183 270 R184 10K -25V

R192 2.2K R193 1.2K -25V

-7.5

INTERNAL TRIGGERING SIGNAL TO D304 ◇4

0.1V/DIV 20µS/DIV

0.5V/DIV 20µS/DIV

VIDEO BRIGHTENING PULSE FROM HORIZONTAL DISPLAY SWITCH, SW430-1R ◇7

-7

1V/DIV 2mS/DIV (X20 SWEEP MAGNIFICATION)

R197 1K

R198 75

C198 250µF

J198 VIDEO OUTPUT

R199 10K

0.5V/DIV 20µS/DIV

+360V UNREG FROM R655 ◇9

R160 2K C160 .005

R162 3K

L162 58-90µH

+12.5

TO UPPER DEFLECTION PLATE, D3

V164 7788 Q164

R164 47 R163 100K C163 .001 C165 .005

+100V

+6.3 +4.2

-25V

R144 12.1K

Q154

C144 18

L159 100nH

+5

R149 3.9K

R154 1.62K

Q144

VERTICAL SIGNAL TO DC RESTORER Q274 ◇3

R148 33K

+9

R143 15K

R166 1K

R168 75 R169 100 VERT GAIN

R267 270 C267 27 C269 7-45 HF COMP -25V

R268 75

R266 1K

R141 226 R240 500 VARIABLE

+100V R242 220K B242 CAL

R245 10K POSITION

R241 178 SW240

R243 15K

R248 33K

+5.8

+9

R254 1.62K

Q244 Q254

+6.6

R249 3.9K

L259 100nH

Q264

C263 .001

R263 100K +7.5

+100V

R264 47

V264 7788

C265 .005

L262 58-90µH +17.5

TO LOWER DEFLECTION PLATE, D4

R262 3K

R244 12.1K C244 18

-25V

0.5V/DIV 20µS/DIV

REFERENCE DIAGRAMS

◇2 RESPONSE SWITCH
◇3 DC RESTORER
◇4 SYNC SEPARATOR
◇7 SWEEP GENERATOR
◇9 POWER SUPPLY
◇10 CRT CIRCUIT & CALIBRATOR

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

VOLTAGES and WAVEFORMS obtained under conditions given on left side of this diagram.

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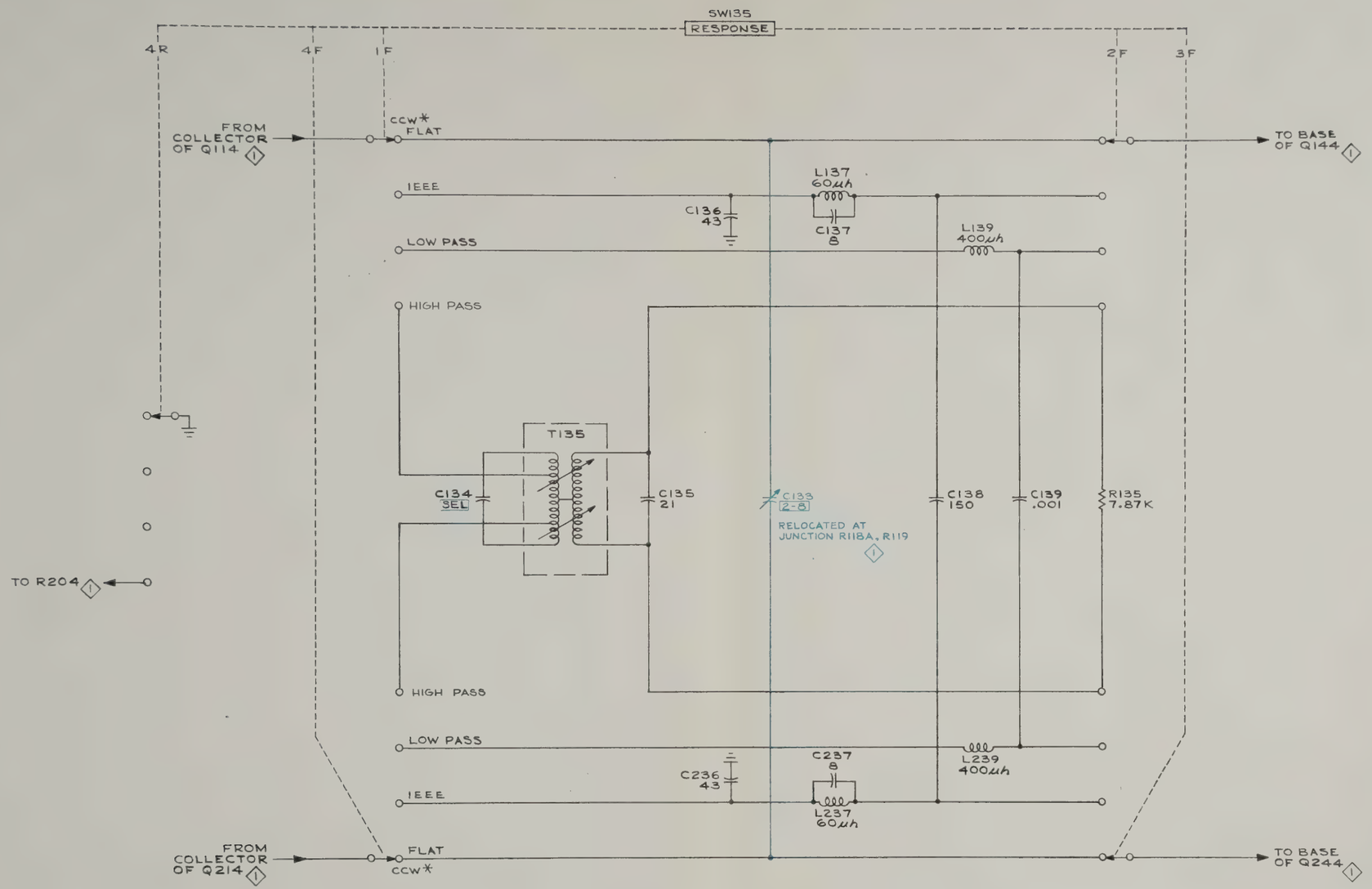

REFERENCE DIAGRAM

① VERTICAL AMPLIFIER

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

NOTES:

1. ALL INACTIVE FILTER SECTIONS GROUNDED AT INPUT AND OUTPUT
2. SWITCH IS MOUNTED IN INSTRUMENT WITH WAFER 4 NEAREST FRONT PANEL
3. * SWITCH ROTATION AS VIEWED FROM INDEX END OF SWITCH - THIS POSITION IS CLOCKWISE ON FRONT PANEL

MRH
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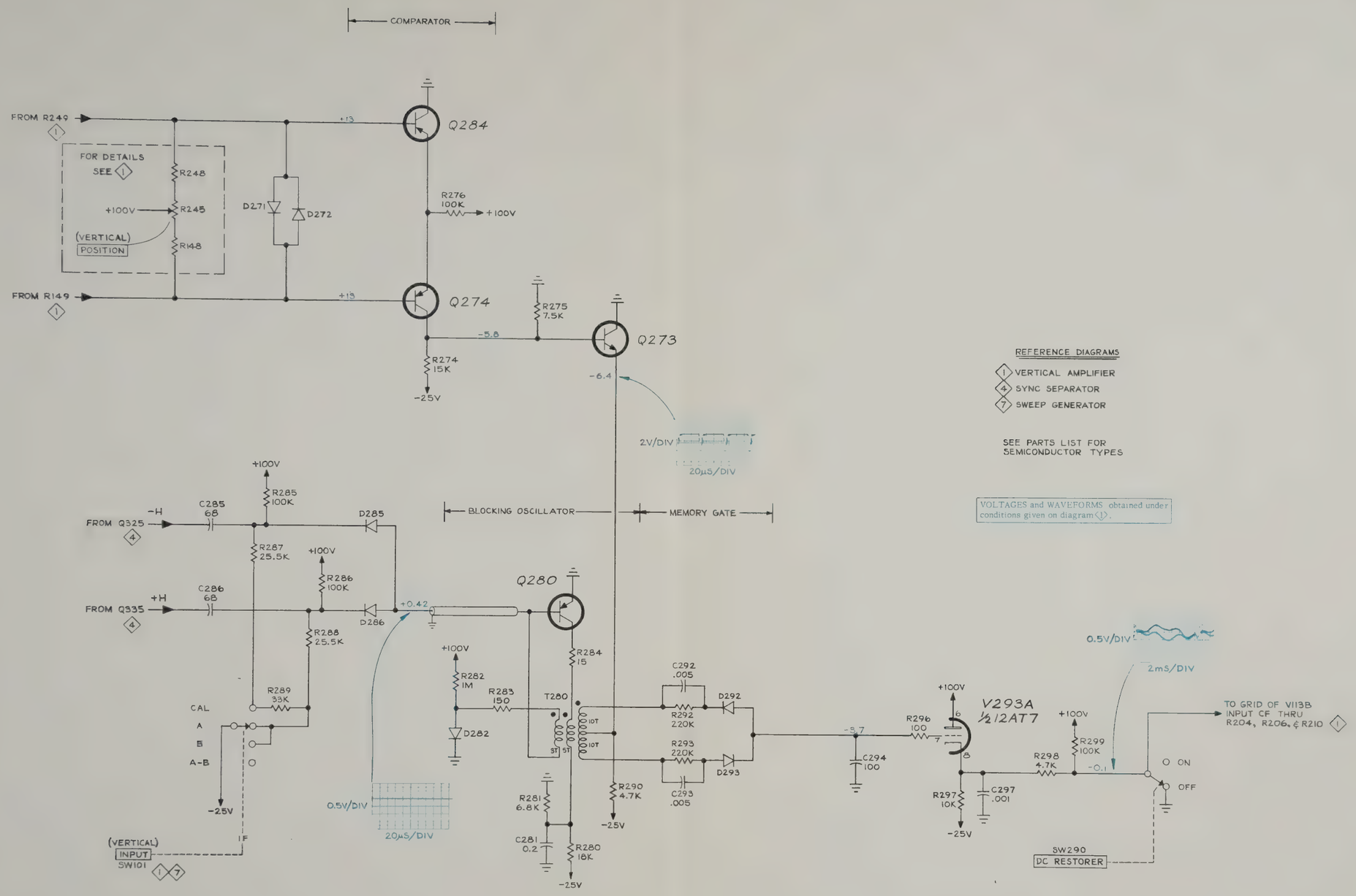
RESPONSE SWITCH ②



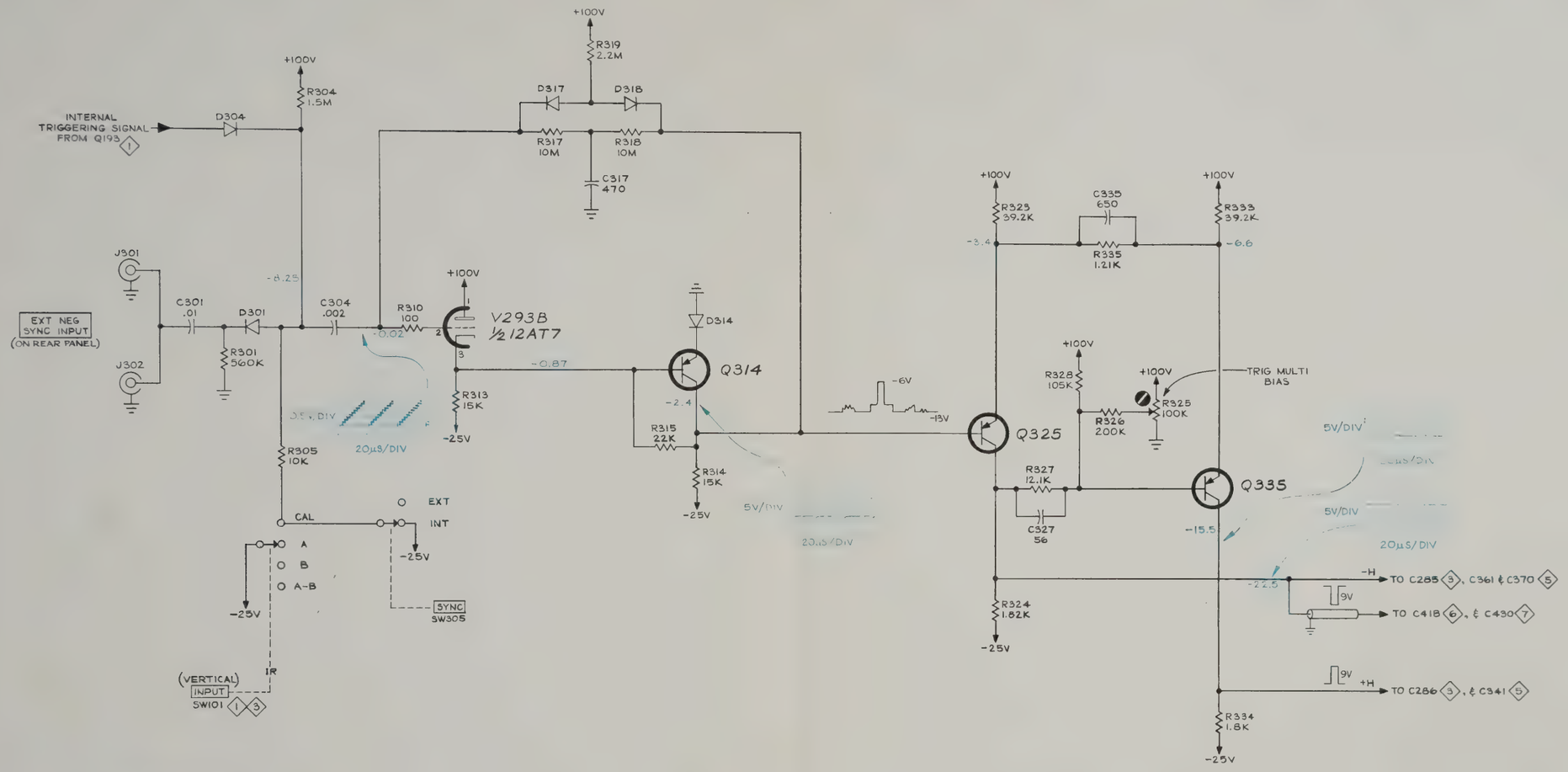
REFERENCE DIAGRAMS

◇1 VERTICAL AMPLIFIER
◇4 SYNC SEPARATOR
◇7 SWEEP GENERATOR

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

VOLTAGES and WAVEFORMS obtained under conditions given on diagram ◇1.

SYNC CLAMPING AMPLIFIER — SYNC REGENERATOR



REFERENCE DIAGRAMS

① VERTICAL AMPLIFIER
③ DC RESTORER
⑤ FIELD SELECTOR
⑥ LINE SELECTOR
⑦ SWEEP GENERATOR

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

VOLTAGES and WAVEFORMS obtained under conditions given on diagram ①.

TYPE RM529 WAVEFORM MONITOR

GN 366

SYNC SEPARATOR ④

S/N 2997-UP

TRIGGER AMPLIFIER | TRIGGER SHAPER | FIELD SELECTOR | DELAY GENERATOR

INT TRIG SIG FROM Q193 ① | EXT NEG SYNC INPUT | J301 | J302 | C301 .01 | D301 | R301 560K | R304 1.5M | +100V | D304 | R305 10K | SW101 (VERT) INPUT ① 1R ④ | CAL | A | B | A-B | SW305 SYNC | INT | EXT | -25V | -25V

R319 3.3M | +100V | D317 | D318 | R317 10M | R318 10M | +100V | C317 470 | R310 100 | C304 .002 | V293B ½12AT7 | Q314 | D314 | R313 15K | -25V | R315 22K | R314 15K | -25V

+100V | R323 39K | C335 650 | R335 1.21K | +100V | R333 39K | TRIG MULTI BIAS | R325 100K | R326 39K | C327 56 | R327 12K | Q325 | Q335

VERTICAL SYNC SEPARATOR | EVEN FIELD RECOGNITION

TO C285 -H | TO C286 +H | GATING PULSE TO DC RESTORER ① | R324 1.82K | -25V | R334 1.8K | -25V

Q344 | R341 6.8K | C342 .005 | R342 2.7K | C341 .001 | R343 18K | -25V | R346 2.2M | C351 27 | R344 3.9K | D346 | R351 10K | C347 100 | -25V

EVEN FIELD SYNC | +100V | R360 500K | R361 470K | C360 .01 | R354 68K | R355 10K | D362 | Q355* | C361 1.8 | +100V | R364 68K | C364 528 | R368 1.5M | R369 10K | D368 | R365 10K | Q365* | C370 330 | D370 | C371 0.1 | R371 33M | D371 | R372 4.7K | R358 24K | -25V

FIELD TRIGGER GENERATOR

R347 10K | -25V | D384 | Q385 | R376 1.8K | R386 1.8K | Q375 | D374 | R385 47K | C385 .001 | R375 47K | C375 .001 | R374 10K | -25V | R377 47K | C374 .001 | R378 1M | D377 | R379 1K | C379 .001 | FIELD TRIG PULSE TO D452 ④

R384 10K | -25V | C384 .001 | R388 1M | D387 | R387 47K | C377 .001 | C387 .001 | SW 380 FIELD SHIFT | EVEN | ODD | C410 .001 | R410 1M | R389 100K | D410 | +100V | R404 150K | R405 12K | R406 150K | -25V | Q415* | D411 | C414 .005 | +100V | R414 45.3K | R415 13.7K | D415 | C420 .001 | D420 | 12T 24T | T420 | R420 470 | Q420 | C424 .005 | R424 82K | -25V | C417 0.22 | +100V | R417 499K | R419 4.7K | Q414* | -25V | Q405*

④ | J501 D | K385 | TO BASE OF Q483 THRU R481 ④ | -25V

(HORIZONTAL) DISPLAY SW430 ④ | 3F | 3F | +100V | 2 FIELD | 2 LINE | .25H/CM | .125H/CM | .25H/CM | .125H/CM | DELAYED LINE | R431 100K | R437 100K | C430 150 | D430 | D436 | LINE TRIG PULSE TO C452 ④ | R430 10K | R438 39K | C436 470 | R436 1K | C427 12 | D427 | R428 15.8K | DELAY | R429 5K | R427 4.7K | -25V

REFERENCE DIAGRAMS
① VERTICAL AMPLIFIER & DC RESTORER
④ SWEEP GENERATOR & HORIZONTAL AMPLIFIER

*DENOTES SPECIAL PART. SEE PARTS LIST.

TYPE RM529 WAVEFORM MONITOR

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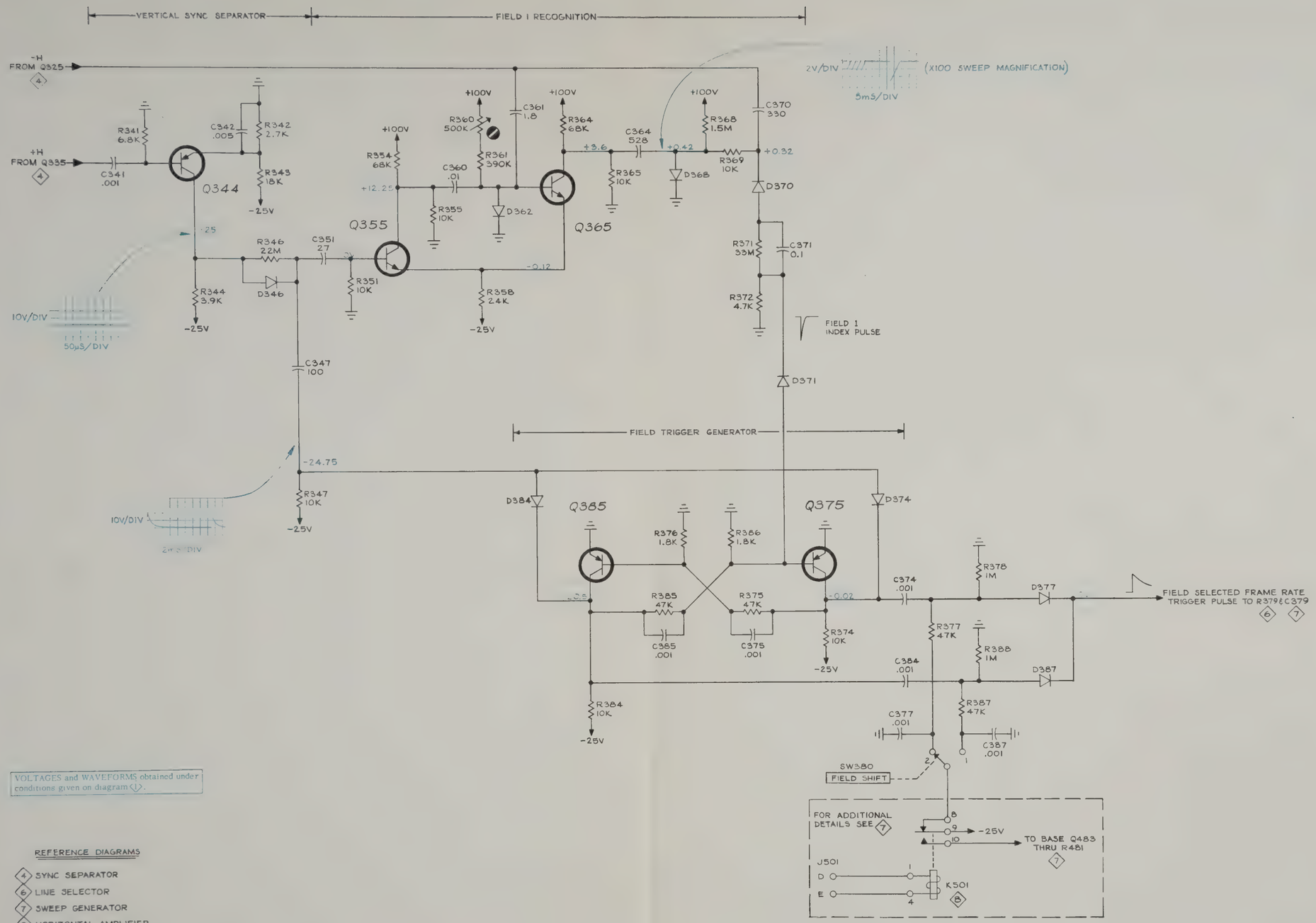
DON 365

TRIGGER GENERATOR

S/N 101 – 2096



VOLTAGES and WAVEFORMS obtained under conditions given on diagram <1>.

REFERENCE DIAGRAMS

- <4> SYNC SEPARATOR
- <6> LINE SELECTOR
- <7> SWEEP GENERATOR
- <8> HORIZONTAL AMPLIFIER

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

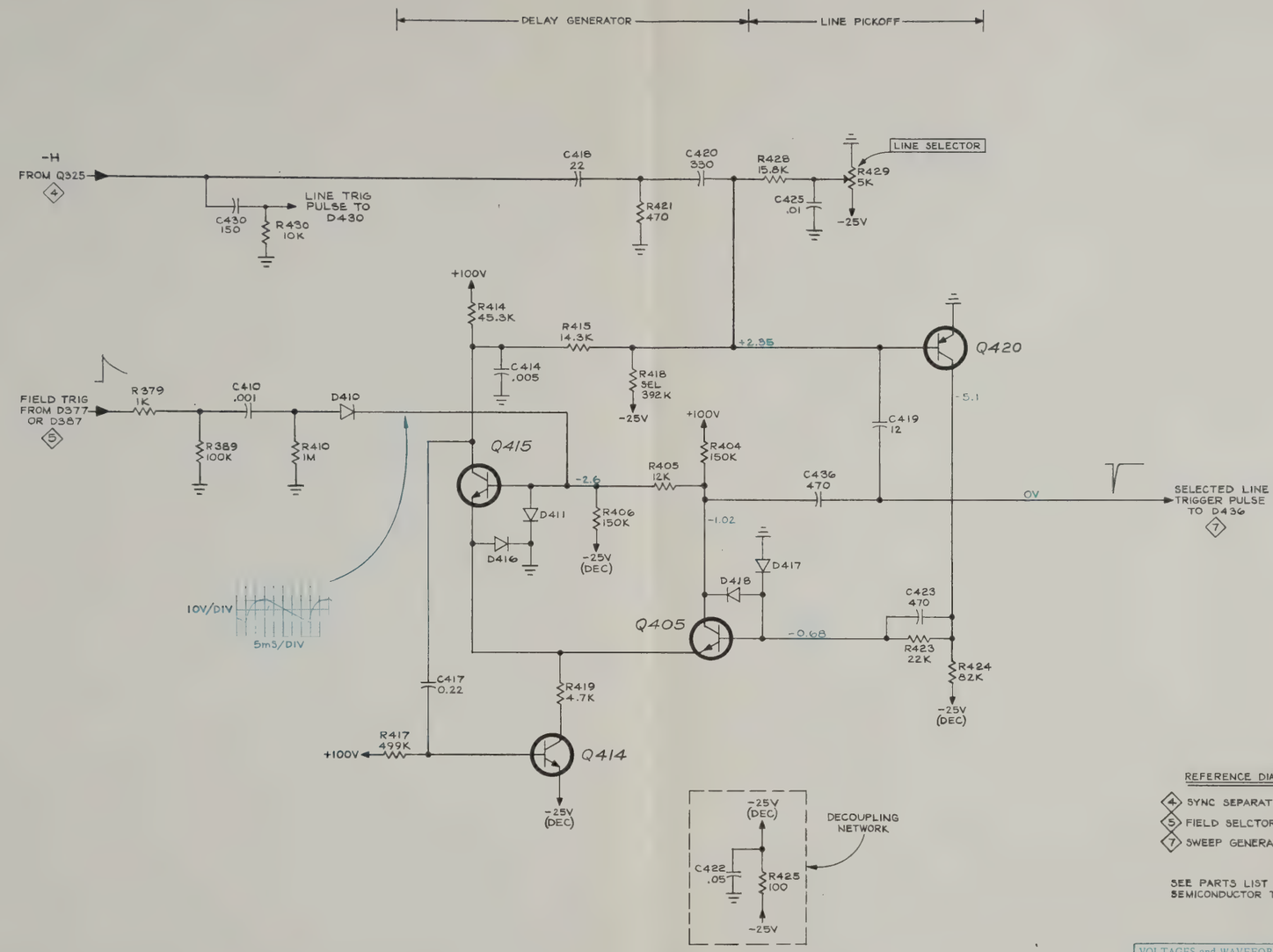
+ TYPE RM529 WAVEFORM MONITOR

G

GN 366

FIELD SELECTOR <5>

S/N 2997-UP



REFERENCE DIAGRAMS

- 4 SYNC SEPARATOR
- 5 FIELD SELCTOR
- 7 SWEEP GENERATOR

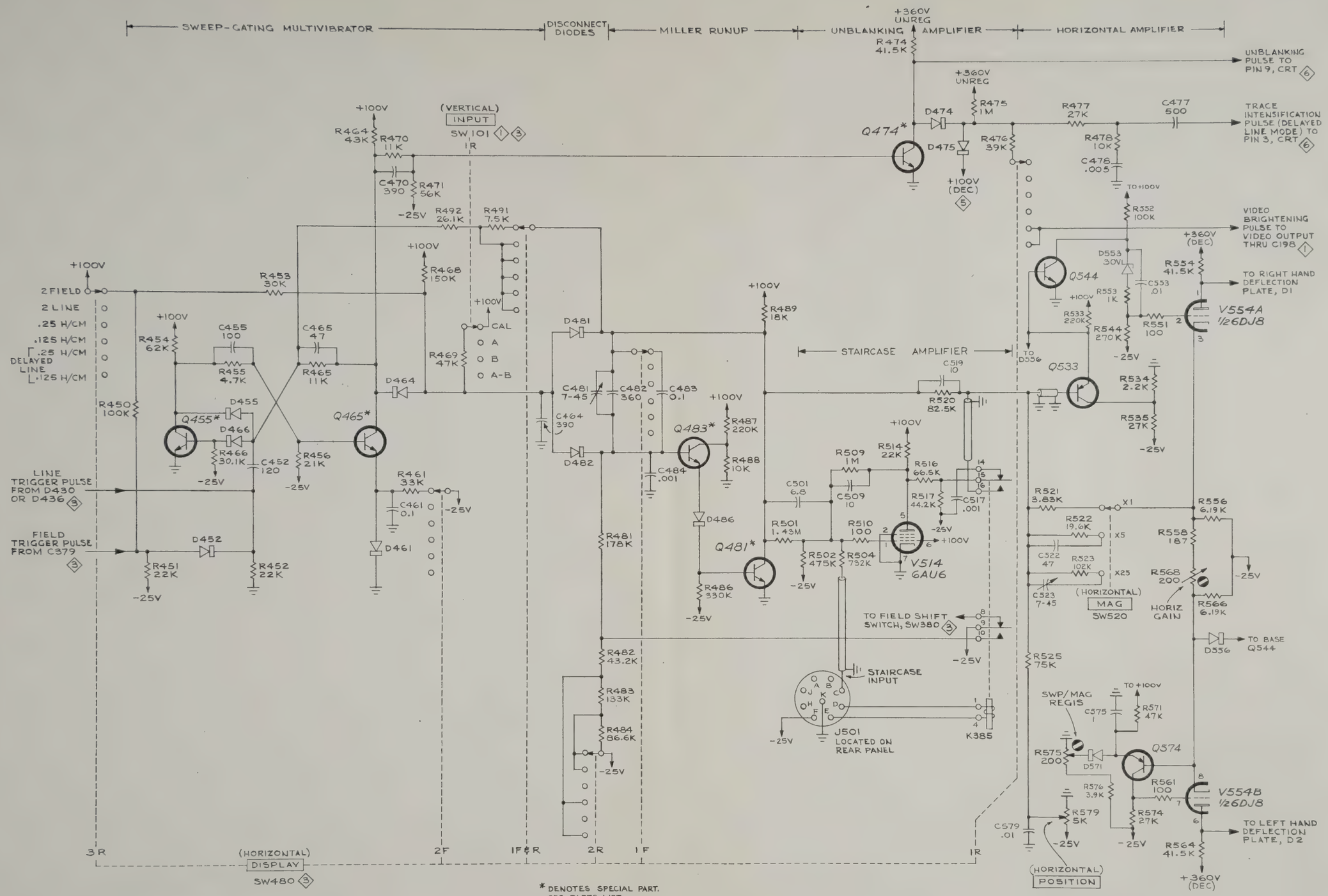
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

VOLTAGES and WAVEFORMS obtained under conditions given on diagram (1).

GN 366

LINE SELECTOR 6

S/N 2997 - UP



* DENOTES SPECIAL PART. SEE PARTS LIST.

REFERENCE DIAGRAMS:

- 1 VERTICAL AMPLIFIER & DC RESTORER
- 3 TRIGGER GENERATOR
- 5 POWER SUPPLY
- 6 CRT CIRCUIT & CALIBRATOR

RM529 WAVEFORM MONITOR

E

MRH 266

SWEEP GENERATOR AND HORIZONTAL AMPLIFIER

S/N 101-2996

(HORIZONTAL) DISPLAY SW 430

3F 3F 3R 2F 1F&R 2R 1F 1R

TRIGGER SELECTOR MATRIX — SWEEP GATING MULTIVIBRATOR — DISCONNECT DIODES — MILLER RUNUP

2 FIELD
2 LINE
.25 H/CM
.125 H/CM
.25 H/CM
.125 H/CM
LINE SELECTOR

+100V
R464 43K
R470 11K
C470 100
D470 30V
R472 220K
R474 41.5K
+360V UNREG
UNBLANKING PULSE TO PIN 9, CRT (10)
TP 474
+0.21
20V/DIV
50μS/DIV
D471
D473
D472
R473
-25V
Q474
D474
R475 1M
+360V UNREG
R477 27K
C477 500
TRACE INTENSIFICATION (LINE SELECTOR MODE) TO PIN 3, CRT (10)
R476 39K
R478 10K
C478 .03
D475
+100V (DEC) (9)
VIDEO BRIGHTENING PULSE TO VIDEO OUTPUT, J198 THRU R197 & C198 (1)

(VERTICAL) INPUT SW 101
1R (1) (3)
R493 392K
R492 26.1K
R491 7.5K

+100V
R453 30K
R468 150K
+1.15
+12.25
-3.95
CAL
A
B
A-B
R469 47K
C464 390
D481
R489 18K
C483 0.1
C481 7-45
C482 360
+1.44
C484 .001
D482
R481 178K
R487 220K
R488 10K
Q483
D486
R486 330K
-25V
Q481
10V/DIV
50μS/DIV
+1.38
SAWTOOTH TO R520 (8)

R454 62K
C455 100
R455 4.75K
C465 47
R465 11K
D455
D466
R466 30.1K
Q455
Q465
D464
C452 120
D456
-H FROM Q325
C462 43
R461A 34.8K
D461
C463 0.1
-25
R457 121K
R458 100K
R456 19.6K
-25V
VIT LINE SEL RANGE
R463 470
D463
D462
R462 2.7K
2V/DIV
50μS/DIV

R445 33K
R431 100K
R437 100K
R450 100K
R448 100K
R449 100K
C430 150
D430
R430 10K
D436
-H FROM Q325 (4)
SELECTED LINE TRIGGER PULSE FROM C436 (6)
R438 39K
FIELD SELECTED FRAME RATE TRIGGER PULSE FROM D377 OR D387 (5)
C379 .001
R451 22K
D452
R452 22K

TO FIELD SHIFT SW 380 (5)
J501
K501
R482 43.2K
R483 133K
R484 86.6
2 FIELD
2 LINE
.25 H/CM
.125 H/CM
.25 H/CM
.125 H/CM
LINE SELECTOR

SW 380 FIELD SHIFT (5)
R461G 1.5K
R461B 3.01K
R461C 3.01K
R461D 3.01K
R461E 3.01K
R461F 3.01K
VAR
SW 461 LINE SELECTOR

REFERENCE DIAGRAMS
(1) VERTICAL AMPLIFIER
(3) DC RESTORER
(4) SYNC SEPARATOR
(5) FIELD SELECTOR
(6) LINE SELECTOR
(8) HORIZONTAL AMPLIFIER
(9) POWER SUPPLY
(10) CRT CIRCUIT & CALIBRATOR

VOLTAGES and WAVEFORMS obtained under conditions given on diagram (1) except as follows:

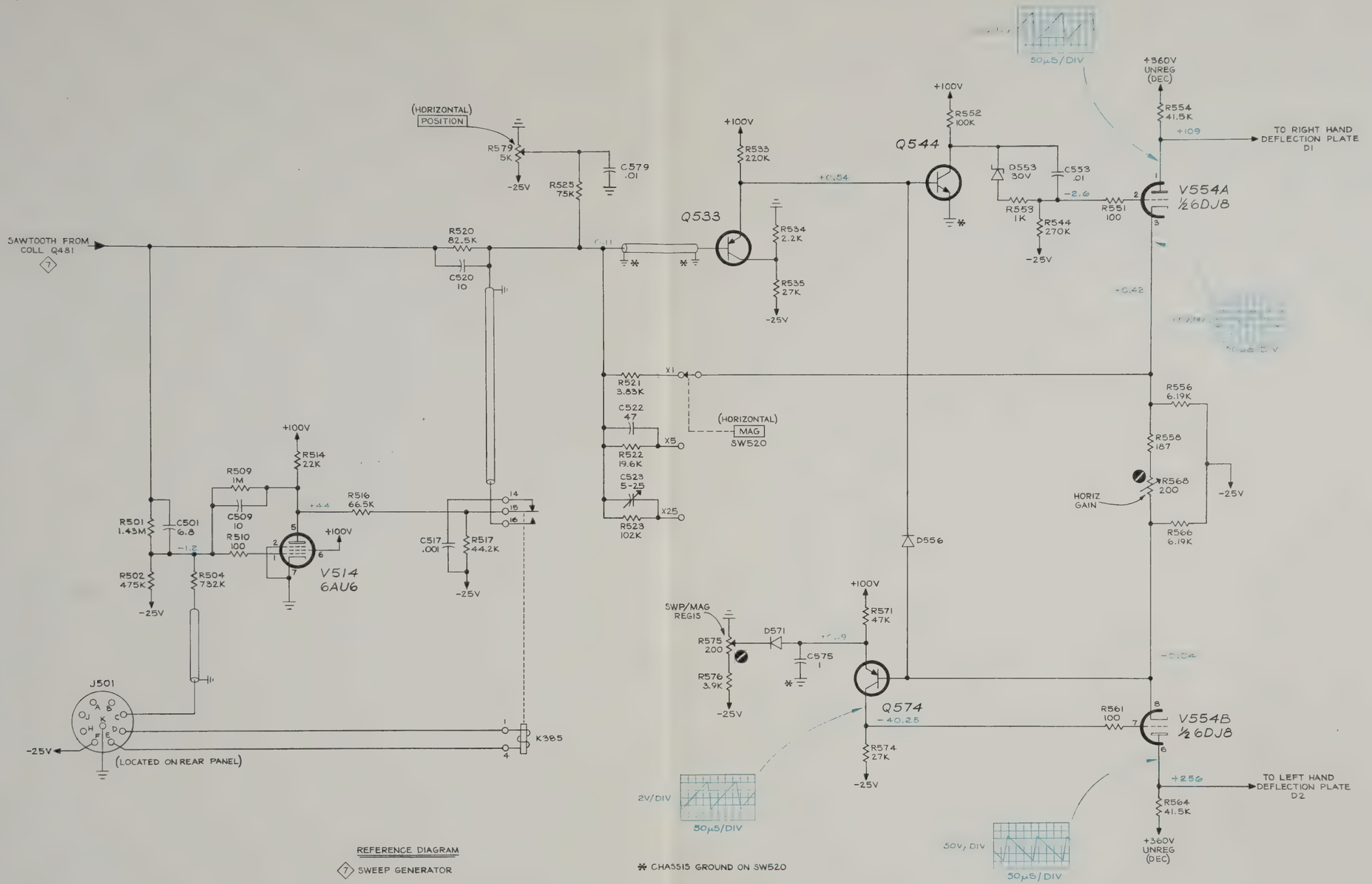
** Set DISPLAY switch to .125 H/CM to obtain waveform.

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

TYPE RM529 WAVEFORM MONITOR

SWEEP GENERATOR (7)

S/N 2997-UP

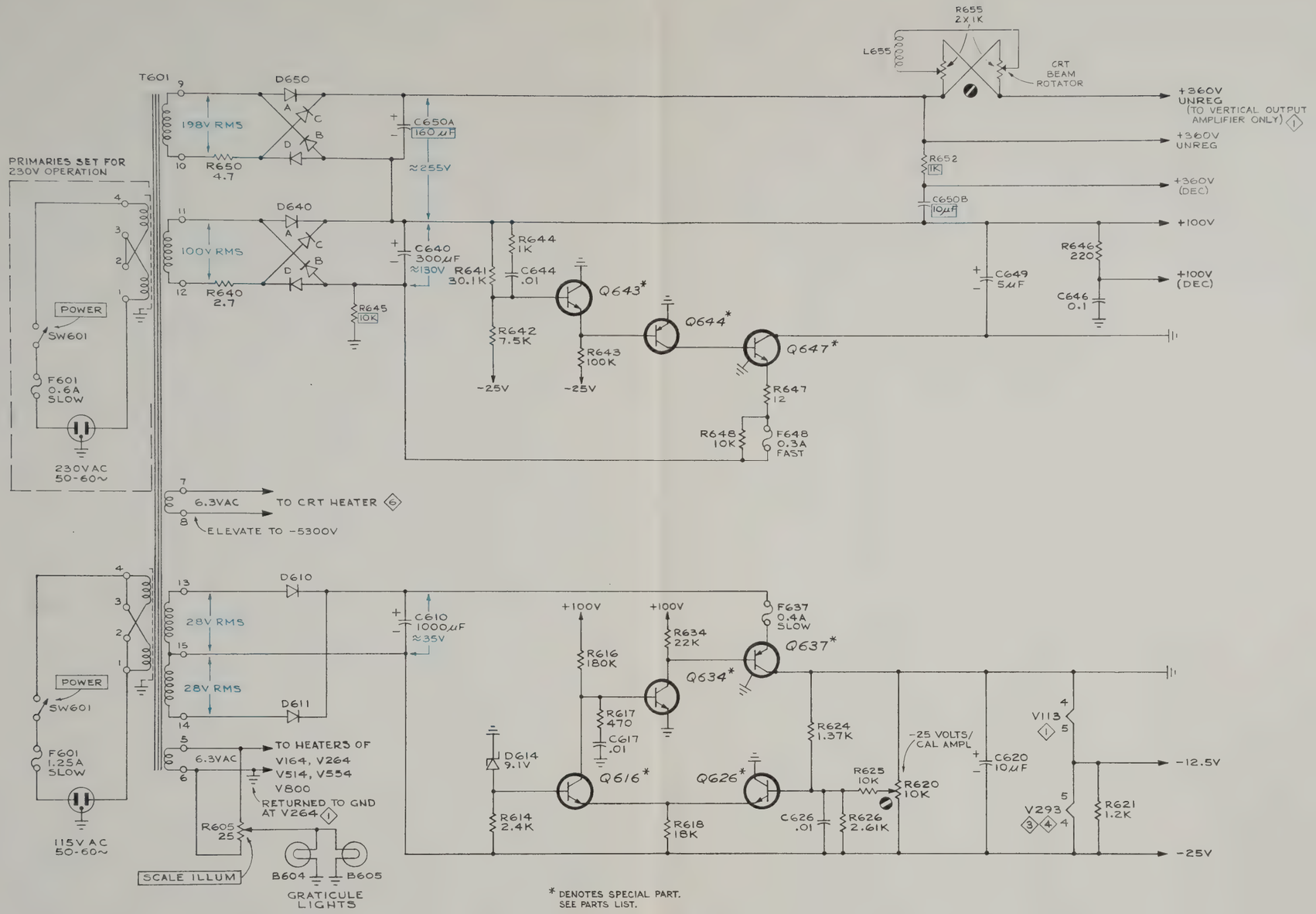


REFERENCE DIAGRAM

(7) SWEEP GENERATOR

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

* CHASSIS GROUND ON SW520



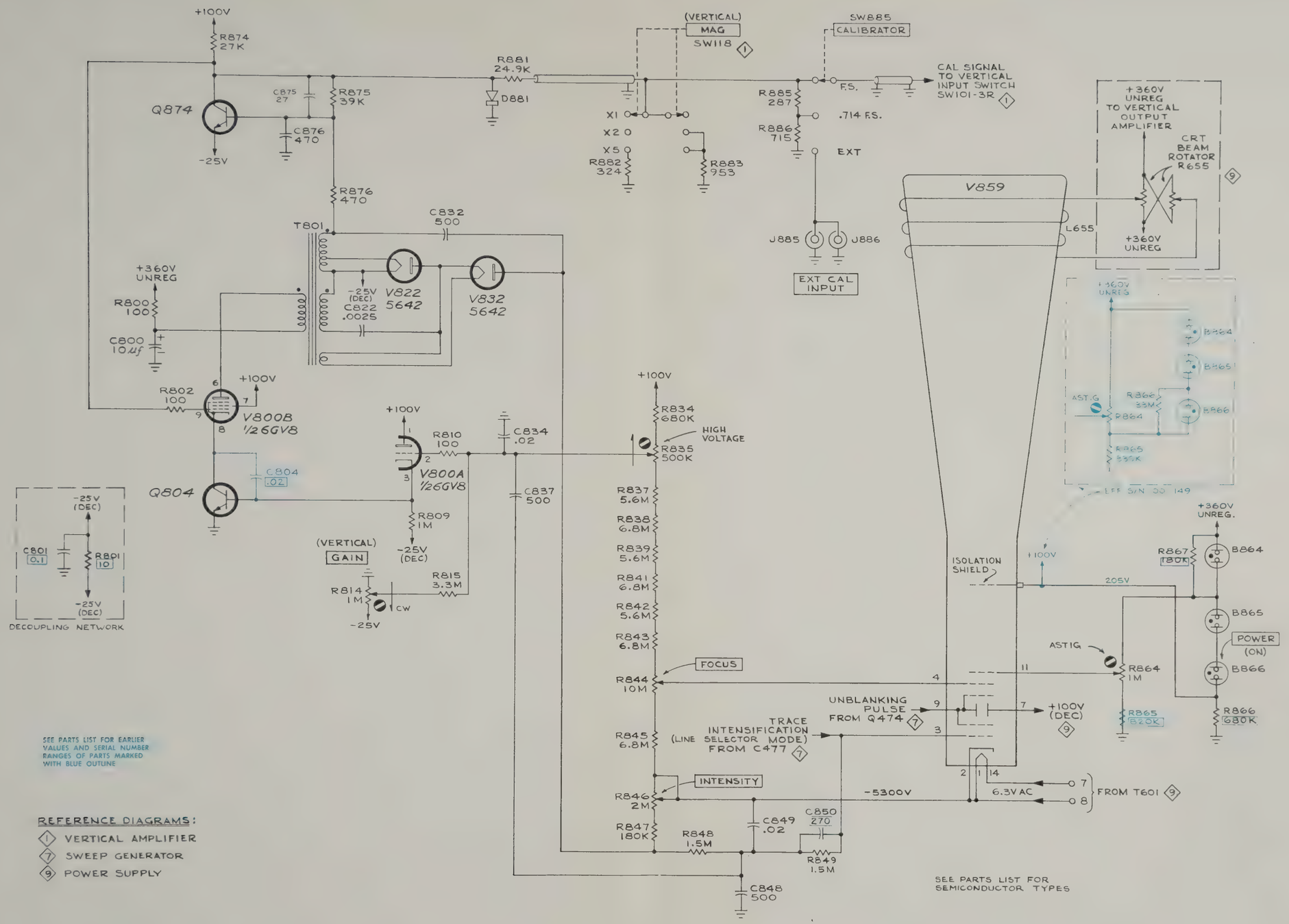
* DENOTES SPECIAL PART. SEE PARTS LIST.

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:

1 VERTICAL AMPLIFIER
3 DC RESTORER
4 SYNC SEPARATOR



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE

REFERENCE DIAGRAMS:

- 1 VERTICAL AMPLIFIER
- 7 SWEEP GENERATOR
- 9 POWER SUPPLY

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

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MRH

RACKMOUNTING

Mounting Method (Figs. 1 and 2)

This instrument will fit most commercial consoles and most 19-inch wide racks whose dimensions conform to EIA specifications.

Fig. 1 shows the instrument installed in a cabinet type rack with slideout tracks. The instrument is locked into the rack by means of pawl fasteners. When the RELEASE knobs on the front panel are turned to release the instrument, the instrument can be pulled out of the rack like a drawer to its fully extended position (see Fig. 2) and then tilted up about 100°. This position permits many routine maintenance functions to be performed without completely removing the instrument from the rack. The slideout tracks easily mount to the cabinet or relay type rack front and rear vertical mounting rails if the inside distance between front and rear rails is within 10 9/16" to 24 3/8".

Some means of support (for example, make extensions for the rear mounting brackets) is needed to support the rear ends of the slideout tracks if the tracks are going to be installed in a cabinet rack whose inside dimension between front and rear rails is not the proper distance (10 9/16" to 24 3/8").

Instrument Dimensions and Weight

The last pullout page in this section shows dimensional drawings exclusive of the power cord and cables.

Rack Dimensions

Width—A standard 19" rack may be used. The dimension or opening between the front rails of the rack must be at least 17 5/8" for a cabinet type rack in which the front lip of the stationary section is mounted **behind the front rail** as shown in Fig. 5b. This dimension allows room on each side of the instrument for the slideout tracks to operate so the instrument can move freely in and out of the rack.

Depth—For proper circulation of cooling air, allow at least 2" clearance behind the rear of the instrument and any enclosure on the rack (see dimensional drawings). At least that much space is also needed for the coaxial cables (unless 90° adapters are used) so they are not bent too sharply. If it is sometimes necessary or desirable to operate the Type RM529 in the fully extended position, use cables that are long enough to reach from the signal source to the instrument.

Rackmounting in a Cabinet Rack (Fig. 2)

General Information

The slideout tracks for the instrument consist of two assemblies, one each for the right and left sides. Each assembly consists of three sections as illustrated in Fig. 3. The stationary section attaches to the front and rear rails of the rack with inside dimension as shown in Fig. 2, the chassis section attaches to the instrument, and the intermediate section fits between the other two sections to allow the instrument to fully extend out of the rack.

The small hardware components included with the slideout track assemblies are shown in Fig. 4. The hardware shown in Fig. 4 is used to mount the slideout tracks to the rack rails having this compatibility; rear rail mounting holes must be drilled, so as to provide the properly spaced mounting holes; front rail holes must be large enough to allow inserting a #10-32 screw; front rail holes must be located on EIA/RETMA/Western Electric or Universal spacing. Because of the above compatibility, there will be some small parts left over.

Stationary and Intermediate Sections Installation

The stationary and intermediate sections for both sides of the rack are shipped as a matched set and should not be separated. The matched sets for both sides are marked 351-040 on the package. Use the following procedure to mount both sets. See Fig. 5 for installation details.

NOTE

If it is desired to mount the rear of the stationary slideout track sections without the bar unts, then one hole must be drilled and tapped for a #10-32 screw in each rear rail. To locate the desired hole: mount the front of the stationary slideout track section; level the stationary section and mark the required hole location.

If it is desired to mount the rear of the stationary slideout track sections with the bar nuts, then two holes must be drilled in each rear rail. The desired holes may be located as above by using the stationary slideout track sections and the bar nuts.

1. If the instrument is to be mounted directly above or below another instrument in the cabinet rack, select the appropriate holes in the front rack rails for the stationary sections using Fig. 5c as a guide.

2. Mount the stationary slideout track sections to the front rack rails using Fig. 5b as a guide.

3. If the rear rack rail holes have been tapped for #10-32 machine screws, mount the left stationary section with hardware provided as shown in Fig. 5a. Using Fig. 5a as a guide, mount the right stationary section in the same manner.

4. If the rear rack rail holes are not tapped to accept #10-32 machine screws, mount the left stationary section with hardware provided as shown in Fig. 5b. Using Fig. 5b as a guide, mount the right stationary section in the same manner.

Adjustments

To adjust the slideout tracks for smooth operation, proceed as follows:

1. Insert the instrument into the rack as shown in Fig. 6.

2. Adjust the slideout tracks for proper spacing as shown in Fig. 7.

Maintenance

The slideout tracks require no lubrication. The special gray finish on the sliding parts is a permanent lubrication.

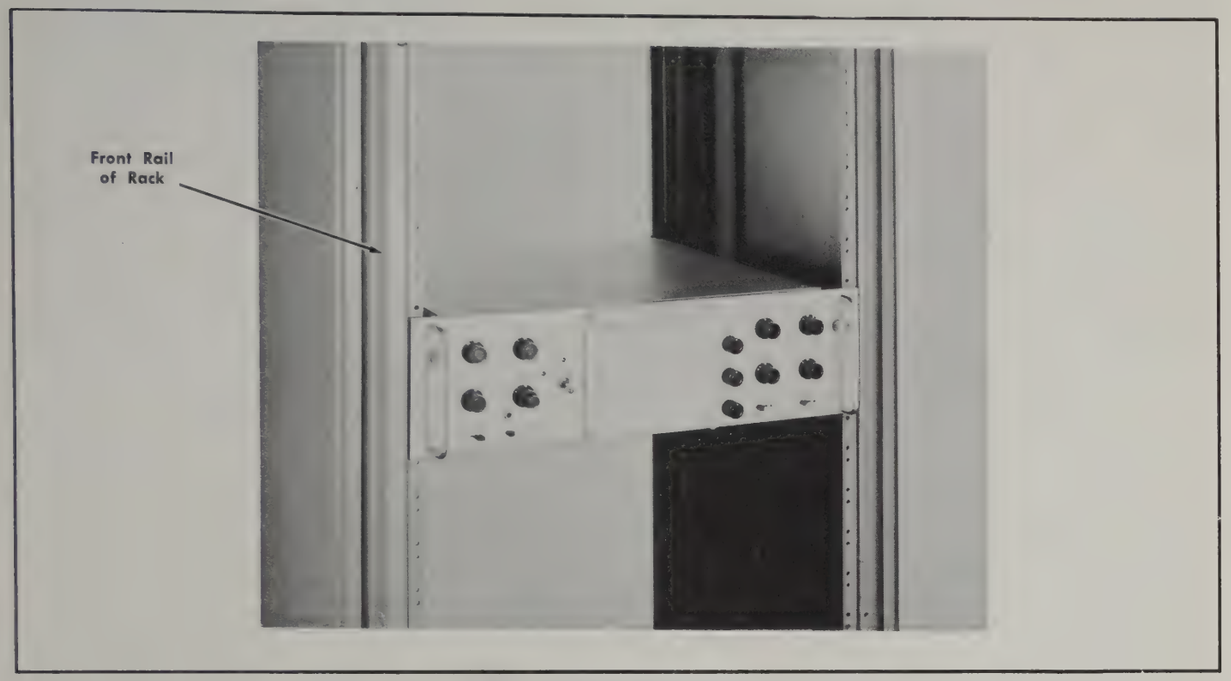


Fig. 1. The Type RM529 installed in cabinet type rack.

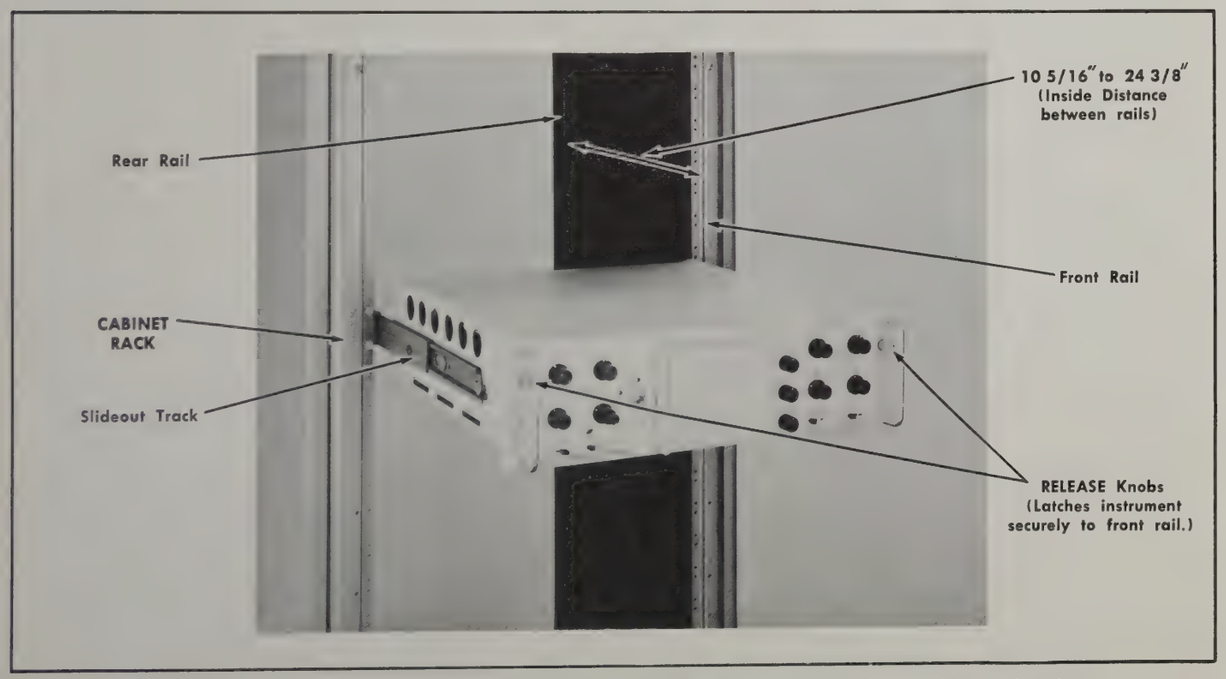


Fig. 2. The Type RM529 supported by slideout tracks mounted between front and rear cabinet rack rails.

Rackmounting—Type RM529

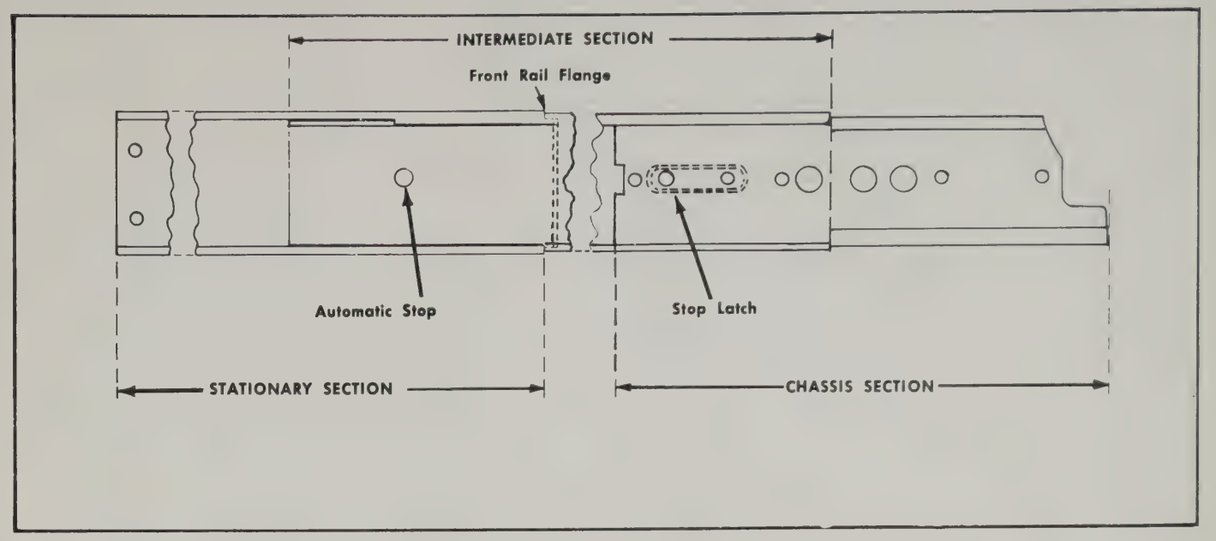


Fig. 3. Illustration showing the slideout track assembly for the right side.

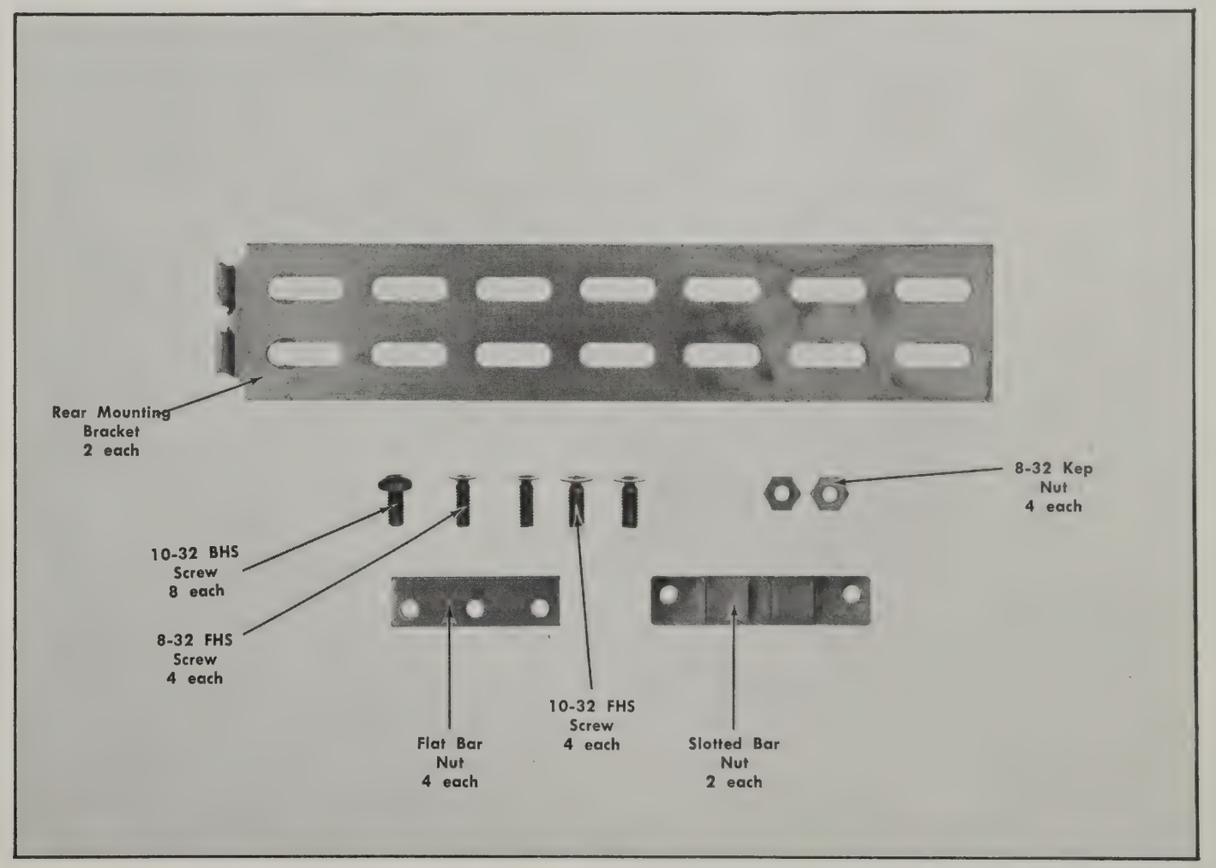
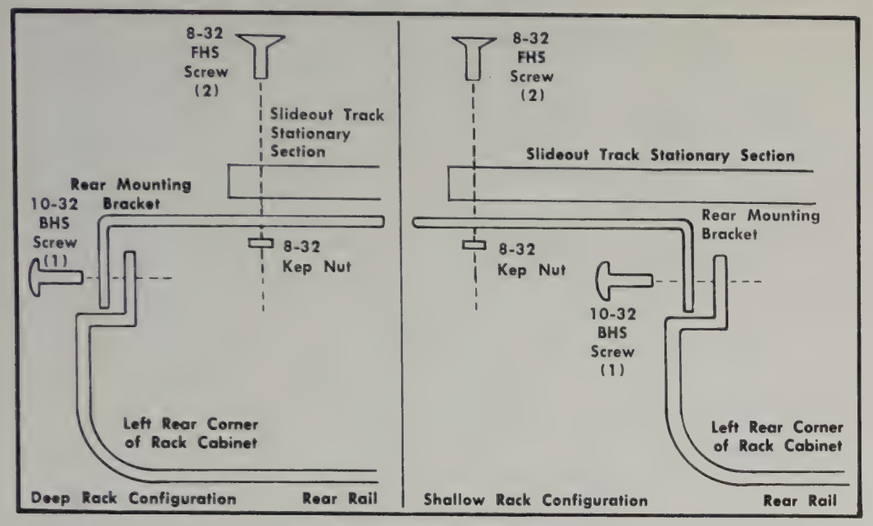
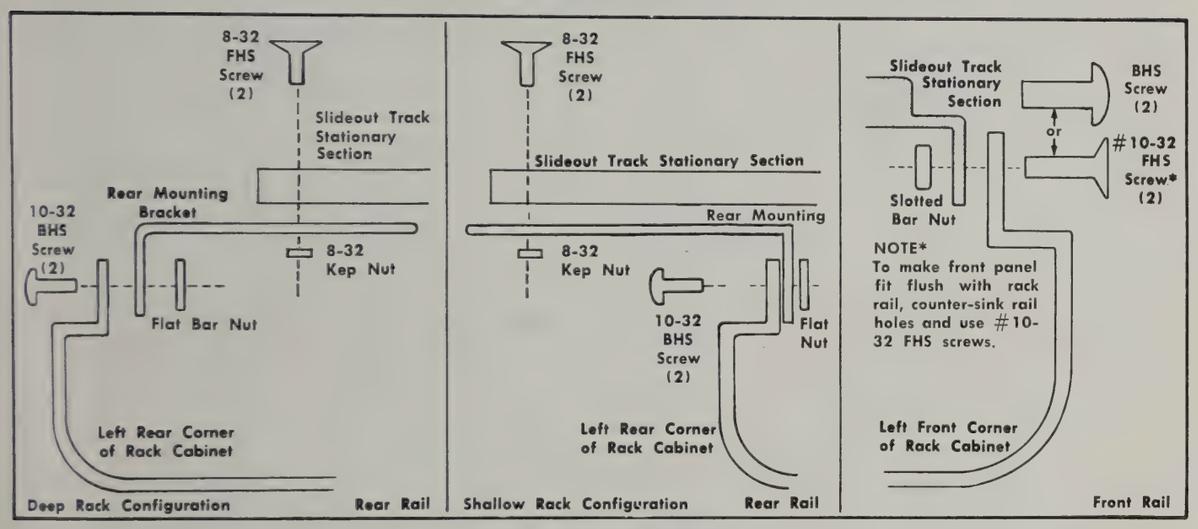


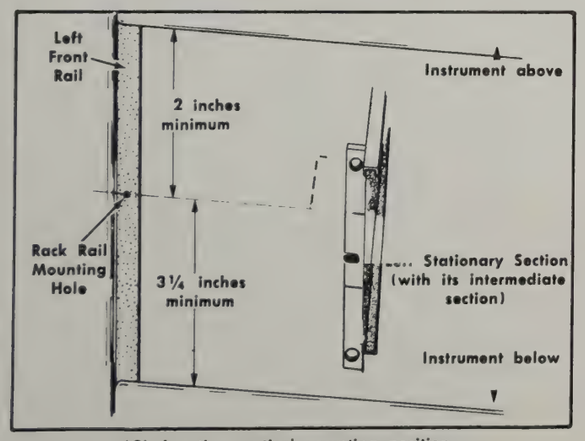
Fig. 4. Small hardware components for mounting the stationary sections to the rack rails.



(A) Rear rack rails tapped #10-32.



(B) Rack rails not tapped.

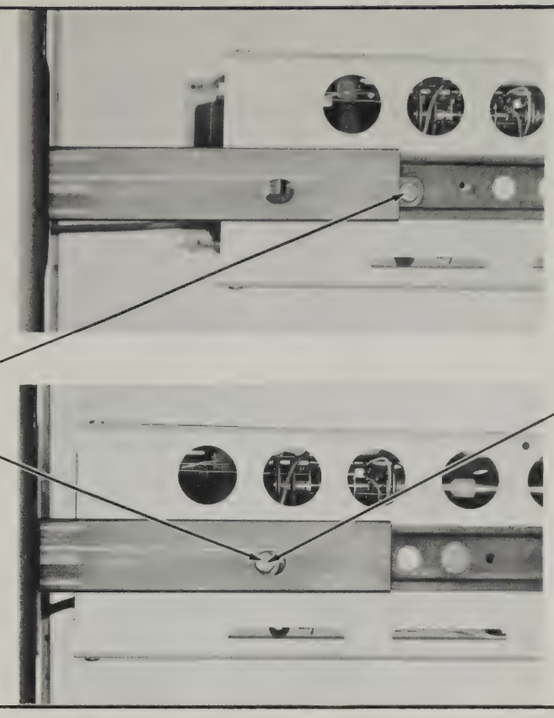


(C) Locating vertical mounting position.

Fig. 5. Mounting the left stationary section with its matched intermediate section (not shown) to rack rails.

TO INSTALL

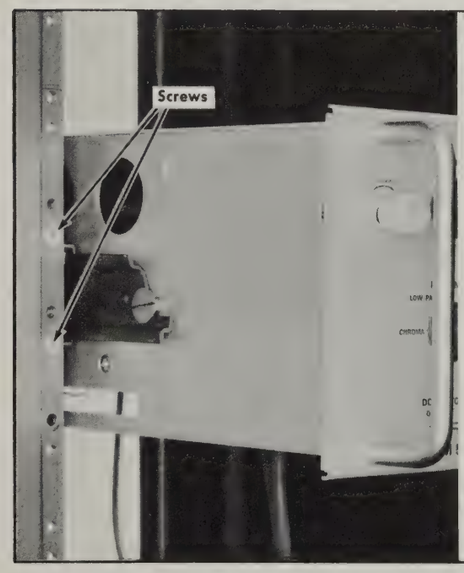
1. Pull the slideout track intermediate sections out to the fully extended position.
2. Insert the instrument chassis sections into the intermediate sections.
3. Press stop latches and push instrument toward rack until the latches snap into their holes.
4. Again press stop latches and push instrument into rack.
5. Lock the instrument in place with the front panel RELEASE knobs.



TO REMOVE

1. Turn the RELEASE knobs to disengage the latches from the front rails.
2. Pull instrument outward until the stop latches snap into the holes.
3. Press stop latches and remove the instrument.

Fig. 6. Installing and removing the instrument.



1. Loosen screws on both sides.
2. Allow slides to seek proper width.
3. Center instrument.
4. Retighten screws.

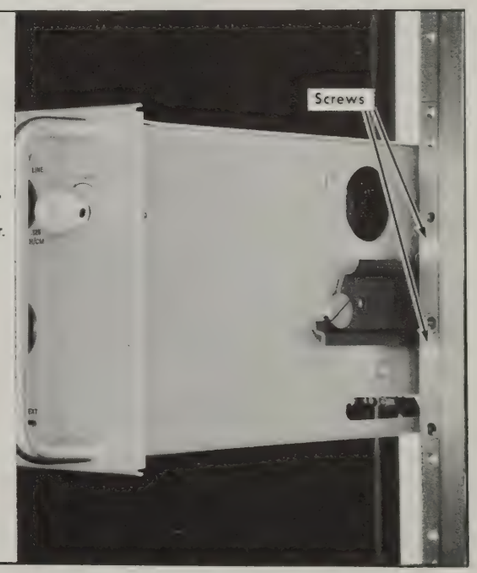
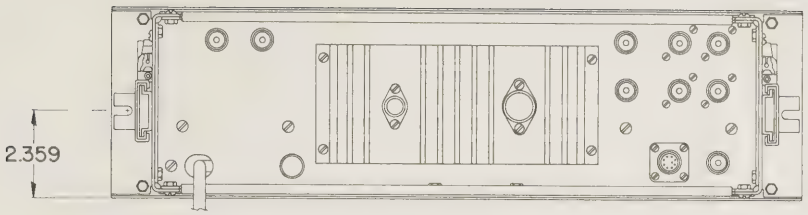
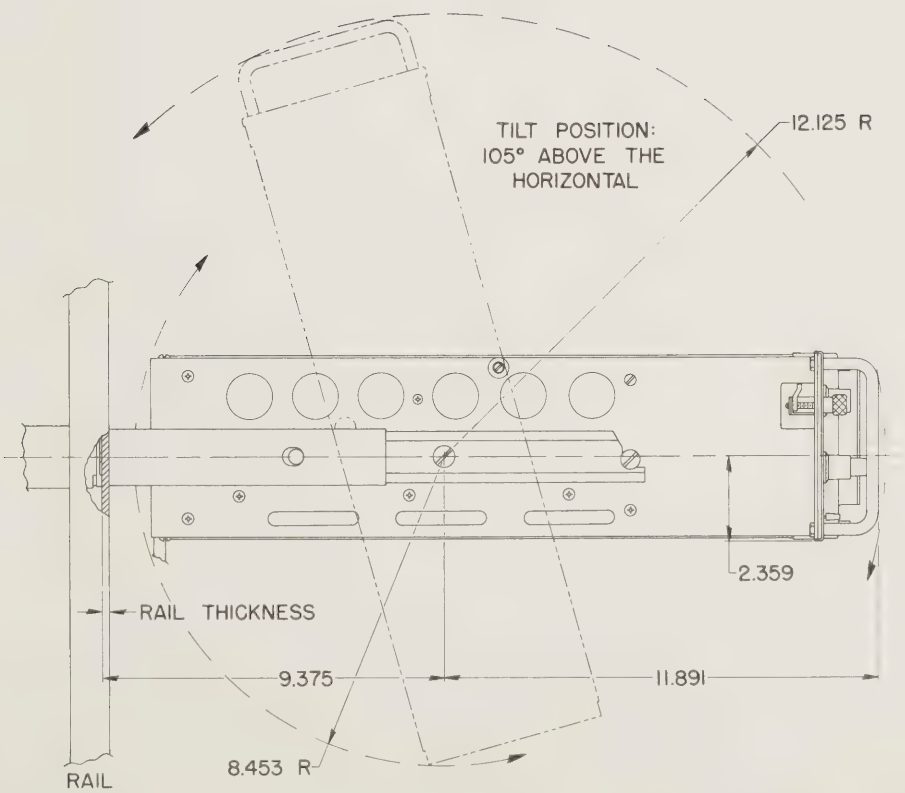
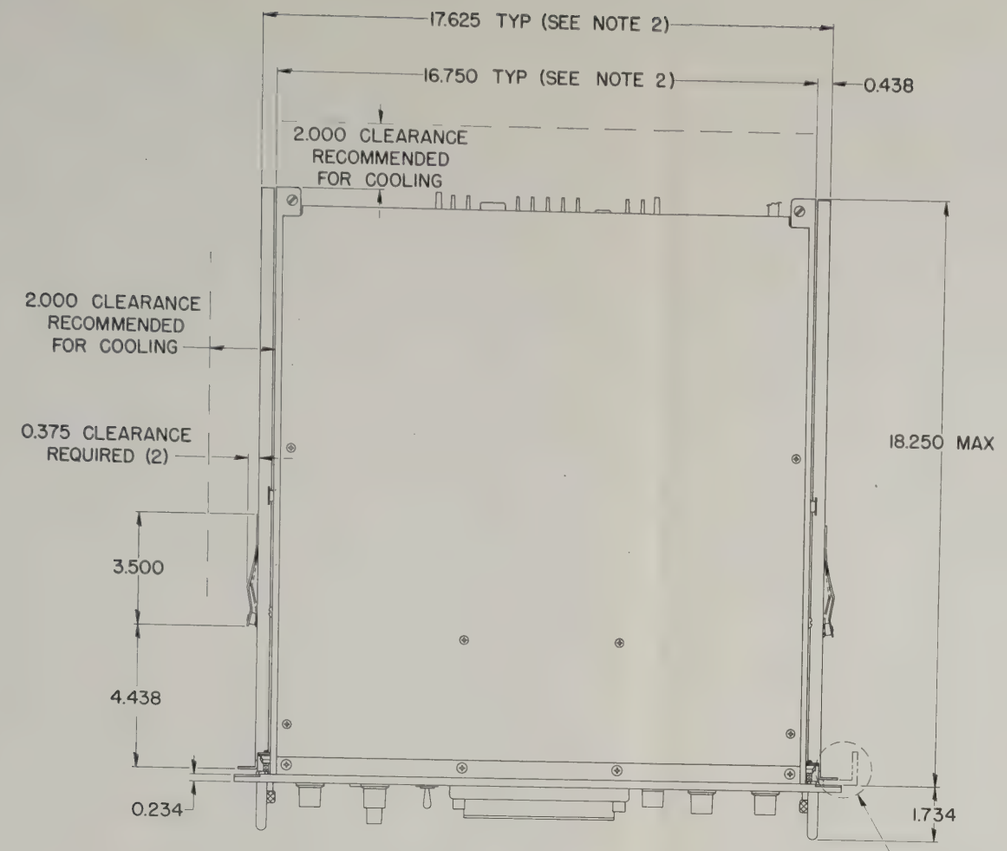


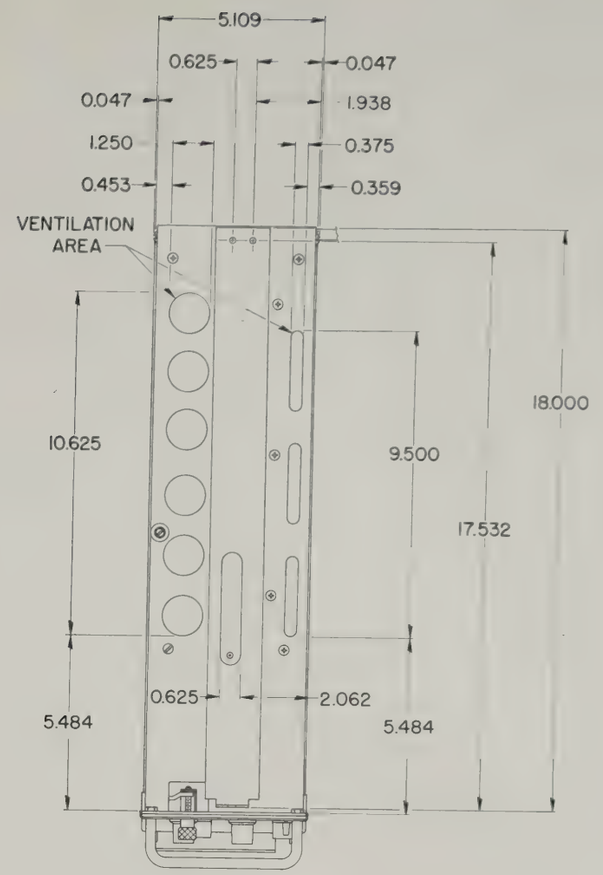
Fig. 7. Adjusting the slideout tracks for smooth sliding action.

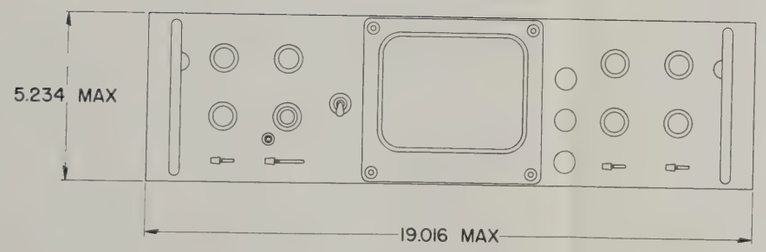

2.359

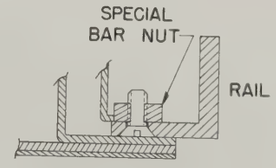
REAR VIEW


TILT POSITION:
105° ABOVE THE
HORIZONTAL
12.125 R
2.359
RAIL THICKNESS
9.375
11.891
8.453 R
RAIL







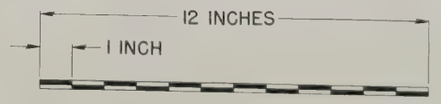


SECTION DETAIL "A"

RECOMMENDED MOUNTING

NOTES:
1. ALL DIMENSIONS ARE REFERENCE DIMENSIONS EXCEPT AS NOTED
2. SUBJECT TO APPROXIMATELY ±0.047 DEVIATION

TYPE RM529



A

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages. If it does not, your manual is correct as printed.

TYPE 529 TENT SN 998
TYPE RM529 TENT SN 2997

PARTS LIST CORRECTION

CHANGE TO:

C361	281-0534-00	3.3 pF	NPO	±0.25 pF
R368	323-0493-00	1.33 MΩ	1/2 W	1%

M10865/366

TYPE 529 TENT SN 998
TYPE RM529 TENT SN 2997

The following should replace the 'Sweep Generator' section in the Circuit Description.

Circuit numbers in ( ) following other circuit numbers refer to the Type RM529 ONLY.

SWEEP GENERATOR

The Sweep Generator is a triggered sweep system for all positions of the DISPLAY switch except the 2 FIELD position at which it is a recurring synchronized sweep. Positive field-trigger pulses stop the sweep in 2 FIELD and both LINE SELECTOR positions (LINE SELECTOR set to a line, lines 16 through 21) operation, negative line-trigger or selected line pulses start the sweep in all other modes of operation. The sweep rate at 2 LINE permits viewing the interlacing of the color burst. The sweep rate at 0.125 H/cm lets you look at every other horizontal line displaying a non-interlaced color burst. Refer to the diagram at the back of this manual during the following circuit description.

Trigger Selector Matrix

Selection of recurrent negative line trigger pulses at the beginning of each horizontal line, or of selected line pulses, is made in a diode switching network of the DISPLAY switch.

When the DISPLAY switch is at a LINE SELECTOR position and the LINE SELECTOR switch is set to a line (lines 16 through 21) position, both D441 (D430) and D444 (D436) are reverse biased so that no negative triggers get to the Sweep Gating Multi. At the same time, D452 is forward biased through R450 so positive field triggers are available to the Sweep Gating Multi.

When the DISPLAY switch is at its LINE SELECTOR positions and the LINE SELECTOR switch is set to VARIABLE, the cathode of D441 (D430) is raised about 9.5 volts positive and the diode is reverse biased so it cannot conduct negative line triggers to the Sweep Gating Multi. D444 (D436) does conduct negative selected line pulses to the Sweep Gating Multi.

When the DISPLAY switch is at 2 LINE, .25 H/CM, or .125 H/CM, D444 (D436) cathode is reverse biased about +29 volts to prevent selected line pulses from getting to the Sweep Gating Multi. D441 (D430) does conduct negative line-trigger pulses to the Sweep Gating Multi.

When the DISPLAY switch is at 2 FIELD, both D441 (D430) and D444 (D436) are reverse biased so that no negative triggers get to the Sweep Gating Multi. At the same time, D452 is forward biased through R450 so positive field triggers are available to the Sweep Gating Multi.

Sweep Gating Multi

The Sweep Generator is operated in two basically different modes of operation as suggested earlier. The Sweep Gating Multi operation is altered from a triggered system for 2 LINE, .25 H/CM, .125 H/CM and both the LINE SELECTOR positions (LINE SELECTOR switch set to VARIABLE) line displays to a stopped-sweep system for both LINE SELECTOR positions (LINE SELECTOR switch set to a line, lines 16 through 21) displays, and to a free-running stopped-sweep system for 2 FIELD displays.

2 LINE DISPLAY. (Vertical INPUT switch at A, DISPLAY switch at 2 LINE.) The Sweep Generator is held in one state by the Sweep Gating Multi until the arrival of a negative trigger pulse. Before receipt of a trigger pulse, the following conditions exist:

a. Q455 is conducting, Q465 is in a state of non-conduction.

b. Both disconnect Diodes are conducting. D482 is applying positive turn-on current from R468 to the Miller Runup input base, while D481 is limiting the turn-on current, as the collector of Q481 pulls down and takes some of the current flow from R468.

c. Q481 collector voltage is at about +1 volt, so that essentially no current is delivered through R520 to the Horizontal Amplifier.

d. The Unblanking Amplifier output is near ground, turning off the CRT beam.

e. The CRT horizontal deflection plates hold the blanked beam at the left side of the CRT (depending upon the setting of the POSITION control).

Q455 is held in conduction by current through the series resistors R464-R465 and D466, limited by R470 current into the base-emitter junction of Q474. The base turn-on current to Q455 is enough to saturate it; however, D455 bypasses some of the intended base current when the collector voltage drops slightly below D466 anode voltage, which prevents the transistor from saturating. (If Q455 were to saturate, the base-emitter junction would hold so many carriers that the transistor could not be turned off quickly.) The fact that Q455 collector voltage is near ground assures that no current reaches the base of Q464, and Q465 remains cut off.

As the negative going line trigger pulse arrives at the base of Q455 through C452, Q455 is turned off. The voltage rise at the collector of Q455 is coupled to the base of Q464, turning it on. As current begins to flow in Q464, its collector voltage drop aids in turning Q455 off and the switching action takes place very rapidly. (Consider the emitter of Q465 as grounded; the components in its emitter circuit are used in 2 FIELD LINE SELECTOR (LINE selector switch set to a line, lines 16 through 21) operation are of no importance in 2 LINE operation.)

Miller Runup

As Q465 collector voltage falls below about +1.3 volts, D464 conducts, and takes the anodes of the Disconnect Diodes toward ground. Both D481 and D482 stop conducting. The timing resistor current that had been flowing through D482 is immediately transferred to the base of Q483. The current that had been flowing in D481 through Q481 is cancelled by a slight drop in voltage at the base of Q481. As Q483 base starts negative, the base of Q481 also starts negative and reduces its collector current, causing its collector voltage to start positive. The timing capacitor couples the positive voltage of Q481 collector back to Q483 base, essentially stopping its negative travel. The result is that the timing capacitor receives a charge at a rate set by the timing resistor, creating a very linear positive-going sawtooth voltage at the collector of Q481. The Miller Runup circuit can be defined as a feedback amplifier, with the feedback element a timing capacitor, and the input resistor a timing resistor; the input signal is the -25-volt supply.

The sweep voltage rises positive until R492 raises the base voltage of Q455 far enough to revert the Sweep Gating Multi. As Q455 conducts, the collector voltage of Q465 raises in the positive direction. D464 stops conducting and R468 raises the base voltage of Q483 positive through D482. This causes collector current in Q481 to increase rapidly. This collector current discharges the timing capacitor at a linear rate set by R468. As Q481 collector voltage approaches the voltage at the base of Q483, D481 takes some of the R468 current and stops the rundown. (D486 offsets the base voltage of Q481 in a direction to limit the quiescent current in D481, permitting the next sweep runup to start linearly.) The rate of rundown is slow enough that the sweep is triggered every other horizontal sync pulse, presenting a non-interlaced color burst. The Sweep Generator then wais for another negative line-trigger pulse to turn off Q455 and start the cycle over again.

2 FIELD DISPLAY. Operation of the Sweep Gating Multivibrator is changed from a state where a trigger is required to start the sweep, to a condition where the sweep starts automatically, and is stopped by a trigger pulse. If the sweep is not running when the DISPLAY switch is set to 2 FIELD, Q464 of the Sweep Gating Multi is not conducting. The DISPLAY switch connects R461A to the -25-volt supply and the emitter voltage starts negative. D461 is reverse biased, and the rate of fall is set by the time constant of R461A - C463. Approximately 1 millisecond after Q465 emitter voltage starts negative, the Sweep Gating Multi switches so that Q465 is on and Q455 off. The sweep voltage runs up as described for 2 LINE operation.

The DISPLAY switch also changes the output of the Trigger Selector Matrix, forward biasing D452 through R450 so that positive pulses will come through D452, and will turn on Q455 to stop the sweep. The positive pulse that turns Q455 on occurs at every other vertical sync pulse. The sweep is stopped, runs down very rapidly due to additional rundown current from R453 in parallel with R468, waits 1 millisecond and automatically starts again, just before the video portion of the next field.

In the event vertical input composite video stops, the sweep will continue to cycle, but instead of positive pulses stopping the sweep, Q455 is turned on by sweep voltage feedback through R491-R492 in the same manner as described for 2 line operation. Thus, the Type 529 Monitor will show a sweep without vertical information when the DISPLAY switch is set to 2 FIELD, but requires a trigger signal from the sweep to operate in all other positions of the DISPLAY switch.

With the INPUT switch set to CAL, R469, is placed in parallel with R468 so the rundown rate will be rapid enough to prepare the sweep to run again at the next calibrator signal transition. This assures a cleanly triggered Calibrator display without the possible jitter caused by a longer rundown.

The runup rate of the Miller Runup circuit is slowed by adding C483 across the timing capacitor used in 2 LINE operation. C483 does not affect the sweep voltage peak value, but changes only the rate at which the spot moves across the CRT. Television systems with different time per field than the 30-hertz U. S. A. rate require a change in the value of C483 to change the sweep rate. For longer time per field, increase C483 value; for less time per field, decrease C483 value. Modification of C483 is normally made at the factory at time of purchase.

The Miller Runup circuit drives both the Horizontal Amplifier and the Staircase Amplifier.

LINE SELECTOR (LINE SELECTOR switch set to line 21)

DISPLAY. Operation of the Sweep Gating Multivibrator is changed from a state where a trigger is required to start the sweep, to a condition where the Sweep Gating Multivibrator starts automatic, runs until a -H pulse latches it and causes it to switch and start the sweep voltage running up. After the sweep voltage has run up, the Sweep Gating Multivibrator is reset by a field selected frame rate trigger pulse. If the sweep is not running when the DISPLAY switch is set to the LINE SELECTOR position (LINE SELECTOR switch set to line 21), Q465 of the Sweep Gating Multi is not conducting. The DISPLAY switch connects R461A to the -25-volt supply through R461B, R461C, R461D, R461E, R461F and R461G (if FIELD switch is set to 2) and the emitter voltage starts negative. D461 is reverse biased, and the rate of fall is set by the time constant of C463-R461A, R461B, R461C, R461D, R461E, R461F and R461G (if FIELD switch is set to 2). At a time, which is determined by the setting of the LINE SELECTOR switch and the FIELD switch, after Q465 emitter voltage starts negative, it will be negative enough to be latched by one of the -H pulses applied through C462 to the emitter of Q465. The latching by the -H pulse causes the Sweep Gating Multi to switch so that Q465 is on and Q455 off. The sweep voltage runs up as described for 2 LINE operation. After the sweep voltage has run up, the Sweep Gating Multi is reset by a field selected frame rate trigger pulse.

Since the VIT LINE SEL RANGE control, R458, varies the base voltage of Q465 a small amount, it is used to set the exact time that Q465 will turn on.

The DISPLAY switch also changes the output of the Trigger Selector Matrix, forward biasing D452 through R450 so that positive pulses will come through D452, and will turn on Q455 to stop the sweep. The positive pulse that turns Q455 on occurs at every other vertical sync pulse. The sweep is stopped, runs down, waits for the time set by the LINE SELECTOR switch and the FIELD switch, then automatically starts again, just before the desired horizontal line.

Unblanking Amplifier

The Unblanking Amplifier (Q474) responds to the Sweep Gating Multi (Q465) collector signal. When there is no sweep, the CRT beam is pulled away from the deflection plates and phosphor screen, preventing any spot from being seen. Q474 collector is near ground at the time of no sweep, turning off the CRT beam. As the Sweep Gating Multi switches states to start a sweep, Q474 is biased to cutoff and its collector rises to +101 volts, limited by conduction of D474 and D475.

The Unblanking Amplifier provides two more output signals during line selector sweep operation. One is the video output intensification discussed with the Vertical Amplifier description. The other is to increase the CRT beam current to intensify the CRT trace for the short duration of the line selector sweeps.

The collector signal of Q474 does not pull down on the trace intensification line; rather, that line is pulled down by R476 and the -5 volts of the Video Output Amplifier circuit between sweeps when the DISPLAY switch is set to either Line Selector position. The collector voltage of Q474 is near ground most of the time in line selector modes, because of the short-duration sweeps

recurring at the 30-hertz rate (once every 33.3 ms). The trace intensification line (at R477-R478 junction) drops to +5 volts in about 2.6 ms as the combination of the R476-R477 discharges C478 and changes the charge on C477.

As the sweep starts, Q474 collector rises quickly, sending an integrated pulse to the CRT grid circuit, R478 permits the step to rise abruptly to +22 volts, then continue to rise at an RC rate. The rising signal to the CRT grid is required to keep the cathode current constant during the intensification period assuring a uniform CRT intensity throughout each sweep.

R476 also conducts current into the 75 ohms of the VIDEO OUTPUT connector, adding about 0.1 volt to the video output to intensify a line of the studio monitor, identifying which line the Type 529 Monitor is viewing.

The following should replace the 'Check Line Selector Operation' step of the Performance Check Procedure.

PERFORMANCE CHECK

Check Line Selector Operation

a. Requirement -- Brightening pulse amplitude must be 100 mV or more.

NOTE

The start of the brightening pulse corresponds to the start of the sweep, as observed on the Type 529 CRT, while the width of the brightening pulse corresponds to the length of the sweep, as observed on the Type 529 CRT.

With the LINE SELECTOR switch set to VARIABLE and the LINE SELECTOR variable set fully counterclockwise, the brightening pulse must start in the vertical blanking time on or before the fifteenth line; with the LINE SELECTOR variable set fully clockwise, the brightening pulse must start after the first 25% of the second field; the display on the Type 529 must remain stable throughout the rotation of the LINE SELECTOR variable control.

With the LINE SELECTOR switch set to 16, the brightening pulse must start at the start of line 16; with the LINE SELECTOR switch set to 17, the brightening pulse must start at the start of line 17; the brightening pulse must start at the start of line 17; with the LINE SELECTOR switch set to 18, the brightening pulse must start at the start of line 18; with the LINE SELECTOR switch set to 19, the brightening pulse must start at the start of line 19; with the LINE SELECTOR switch set to 20, the brightening pulse must start at the start of line 20; with the LINE SELECTOR switch set to 21 the brightening pulse must start at the start of line 21.

b. Connect a 75 ohm coaxial cable from the VIDEO OUTPUT connector of the Type 529 to the vertical input connector of the test oscilloscope.

c. Set the test oscilloscope controls as follows:

Input Selector	AC
Volts/Div	0.02
Time/Div	2 ms
Triggering Mode	Adjusted for stable display
Trigger Slope	+ External

NOTE

The external triggering signal must be at the video field rate.

d. Set the Type 529 DISPLAY switch to LINE SELECTOR .125 H/CM and the LINE SELECTOR switch to VARIABLE.

e. Rotate the LINE SELECTOR variable control fully counterclockwise.

f. Check -- The position (in time) and the amplitude of the brightening pulse on the test oscilloscope. The brightening pulse must be at least 100 mV high and its start should be on or before the 15th line.

g. Rotate the LINE SELECTOR variable control fully clockwise.

h. Check -- The position (in time) and the amplitude of the brightening pulse on the test oscilloscope. The brightening pulse must be at least 100 mV high and its start must occur after the first 25% of the second field.

i. Set the LINE SELECTOR switch to each numbered line position.

j. Check -- That the brightening pulse is at least 100 mV high and that it starts at the start of the line that the LINE SELECTOR switch is set to.

k. Set the FIELD switch to ONE and repeat parts d through j.

NOTE

LINE 10 starts at the frist horizontal pulse preceding the last equalizing pulse in both fields (field one and two). Lines 16 through 21 can be found by counting forward from this point of reference.

The following should be inserted immediately after Step 23 of the Calibration Section.

CALIBRATION

POWER and SCALE ILLUM	2/3 clockwise
FOCUS	Midrange

INTENSITY	Adjust for normal display brightness
GAIN	Midrange

VERTICAL Controls

RESPONSE	FLAT
DC RESTORER	OFF
INPUT	A
VOLTS FULL SCALE	1.0
VARIABLE (VOLTS FULL SCALE)	CALIB
CAL	.714 F.S.
POSITION	Midrange

HORIZ Controls

POSITION	Midrange
SYNC	INT
MAG	X1
DISPLAY	LINE SELECTOR .125 H/CM
FIELD	TWO
LINE SELECTOR switch	21

23A. Check Line Selector Brightening Pulse Amplitude

a. Apply one volt of composite video to the right VIDEO INPUTS A connector.

b. Connect a 75-ohm termination to the left VIDEO INPUTS A connector.

c. Connect a 75-ohm coaxial cable from the VIDEO OUTPUT connector of the Type 529 to the vertical input connector of the test oscilloscope.

d. Connect a 1X probe from the appropriate Trigger Input connector of the test oscilloscope to the junction of D377 and D387.

e. Set the test oscilloscope controls as follows:

Input Selector	AC
Volts/Div	0.02
Time/Div	2 ms

Triggering Mode	Adjusted for stable display
Trigger Slope	+ External

NOTE

The external triggering signal must be at the video field rate.

f. Check that the brightening pulse amplitude is at least 100 mV high.

23B. Adjust VIT LINE SEL RANGE (R458)

a. Test equipment setup is given in step 23A.

b. Connect a DC voltmeter between the center arm of R458 and ground.

NOTE

Before proceeding with this step, the position of the LINE SELECTOR should be checked to insure that the knob has not been misaligned.

c. Adjust the VIT LINE SEL RANGE control (R458) so the brightening pulse just starts to jump between the 21st and 22nd lines as observed on the test oscilloscope.

NOTE

LINE 10 starts at the first horizontal pulse preceding the last equalizing pulse in both fields (field one and two). Lines 16 through 21 can be found by counting forward from this point of reference.

d. Note the DC voltmeter reading

e. Adjust the VIT LINE SEL RANGE control (R458) so the brightening pulse just starts to jump between the 21st and 20th as observed on the test oscilloscope.

f. Note the DC voltmeter reading.

g. Adjust the VIT LINE SEL RANGE control (R458) for a DC voltmeter reading half way between the two readings noted in parts d and f of this step.

h. Disconnect the DC voltmeter.

23C. Check Line Selector Operation

a. Test equipment setup is given in step 23A.

b. Rotate the LINE SELECTOR variable control fully counterclockwise.

c. Check the position (in time) of the brightening pulse on the test oscilloscope. The brightening pulse must start on or before the 15th line.

d. Rotate the LINE SELECTOR variable control fully clockwise.

e. Check the position (in time) of the brightening pulse on the test oscilloscope. The brightening pulse must start after the first 25% of the second field.

f. Set the LINE SELECTOR switch to each numbered line position.

g. Check that the brightening pulse starts at the start of the line that the LINE SELECTOR switch is set to.

h. Set the FIELD switch to ONE and repeat parts b through g.

NOTE

LINE 10 starts at the first horizontal pulse preceding the last equalizing pulse in both fields (field one and two). Lines 16 through 21 can then be found by counting forward from this point of reference.

i. Disconnect the composite video signal and the test oscilloscope from the Type 529 or RM529.

TYPE 529 TENT SN 998
TYPE RM529 TENT SN 2997

PARTS LIST CORRECTION

CHANGE TO:

R454	Selected	62 kΩ Nominal Value
R457	Selected	121 kΩ Nominal Value

This correction supersedes the parts list correction of M10330.

PARTS LIST CORRECTION

REMOVE:

C461	283-0081-00	0.1 µF	25 V		
R461	316-0333-00	33 kΩ	1/4 W		
R471	316-0563-00	56 kΩ	1/4 W		

ADD:

C462	283-0600-00	43 pF	mica	±5%	500 V
C463	285-0595-00	0.1 µF	PTM	±1%	100 V
D456	152-0185-00	Replaceable by 6185			
D462	152-0185-00	Replaceable by 6185			
D463	152-0075-00	Replaceable by 6075			
D470	152-0142-00	Replaceable by 1N972			
D471	152-0061-00	Replaceable by 6061			
D472	152-0185-00	Replaceable by 6185			
D473	152-0185-00	Replaceable by 6185			
R445	302-0333-00	33 kΩ	1/2 W	10%	
R448	316-0104-00	100 kΩ	1/4 W	10%	
R449	316-0104-00	100 kΩ	1/4 W	10%	
R457	323-0393-00	121 kΩ	1/4 W	10%	
R458	311-0026-00	100 kΩ	Var		
R461A	321-0341-00	34.8 kΩ	1/8 W	1%	
R461B	321-0239-00	3.01 kΩ	1/8 W	1%	
R461C	321-0239-00	3.01 kΩ	1/8 W	1%	
R461D	321-0239-00	3.01 kΩ	1/8 W	1%	
R461E	321-0239-00	3.01 kΩ	1/8 W	1%	
R461F	321-0239-00	3.01 kΩ	1/8 W	1%	
R461G	321-0210-00	1.5 kΩ	1/8 W	1%	
R462	315-0272-00	2.7 kΩ	1/4 W	5%	
R463	315-0471-00	470 kΩ	1/4 W	5%	
R472	316-0224-00	220 kΩ	1/4 W	10%	
R473	316-0563-00	56 kΩ	1/4 W	10%	
R493	323-0346-00	39.2 kΩ	1/2 W	1%	

	Unwired	Wired	
SW461	260-0793-00	262-0773-00	Rotary

CHANGE TO:

C470	281-0523-00	100 pF	±20 pF	500 V	
D461	152-0182-00	Replaceable by 6185			
Q455	151-0190-00	Replaceable by 2N3904			
Q465	151-0190-00	Replaceable by 2N3904			

R429	311-0360-01	5 kΩ	Var	10 turns
R455	321-0258-00	4.75 kΩ	1/8 W	1%
R456	321-0317-00	19.6 kΩ	1/8 W	1%

	Unwired	Wired	
SW380	260-0640-00		Lever
SW430	260-0657-00	262-0688-01	Rotary

Text Correction

Text page 5-9

This insert replaces step 29 of the calibration procedure if the equipment is not available for calibrating your instrument as noted in the manual. (See Fig. 1 for appropriate method of actuating relay K385.)

Check J501 Staircase Input

a. Wire the 9-pin plug connector (Tektronix Part No. 134-0049-00) as shown in Fig. 2. Make sure that the 2 μF capacitor is in series between the Type RM529 J501 connector pin C and the output of the square-wave generator.

b. Connect the plug to J501 on the Type RM529.

c. Connect a 12 volt, 120 hertz signal from a Type 105 square-wave generator to pin C of the plug via the 2 μF capacitor.

d. Connect a test oscilloscope to the monitoring point to measure the output amplitude of the square-wave generator.

e. Apply one volt of composite video to the upper VIDEO INPUTS A connector.

f. Connect a 75 ohm termination to the lower VIDEO INPUTS A connector.

g. Check for a display as shown in Fig. 3A. Note right hand display position.

h. Reduce the signal from the square-wave generator to 8 volts.

i. Check for a display as shown in Fig. 3B. Note right hand display position.

j. Reduce the signal from the square-wave generator to 4 volts.

k. Check for a display as shown in Fig. 3C. Note right hand display position.

l. Check that each display had some separation from its neighbors.

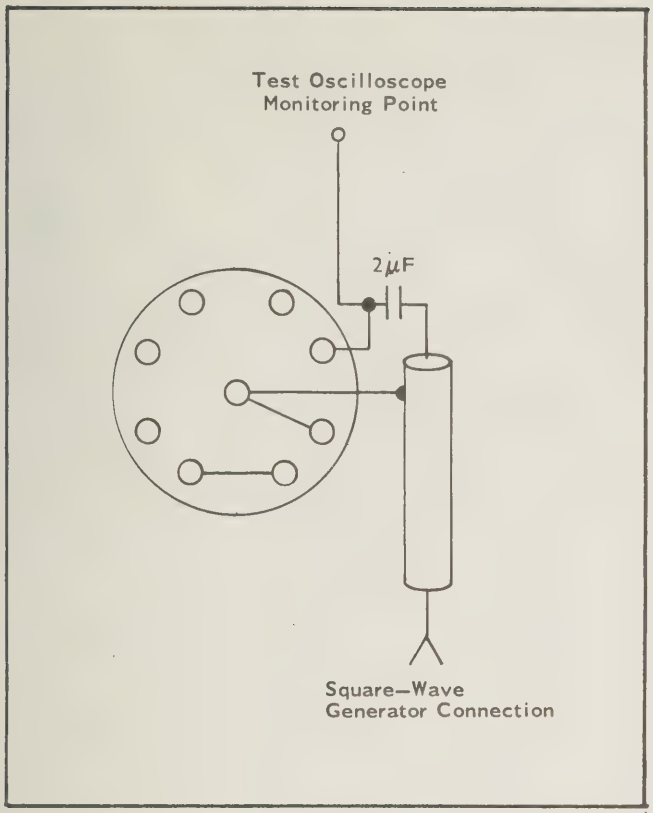

Test Oscilloscope
Monitoring Point
2μF
Square—Wave
Generator Connection

Fig. 2

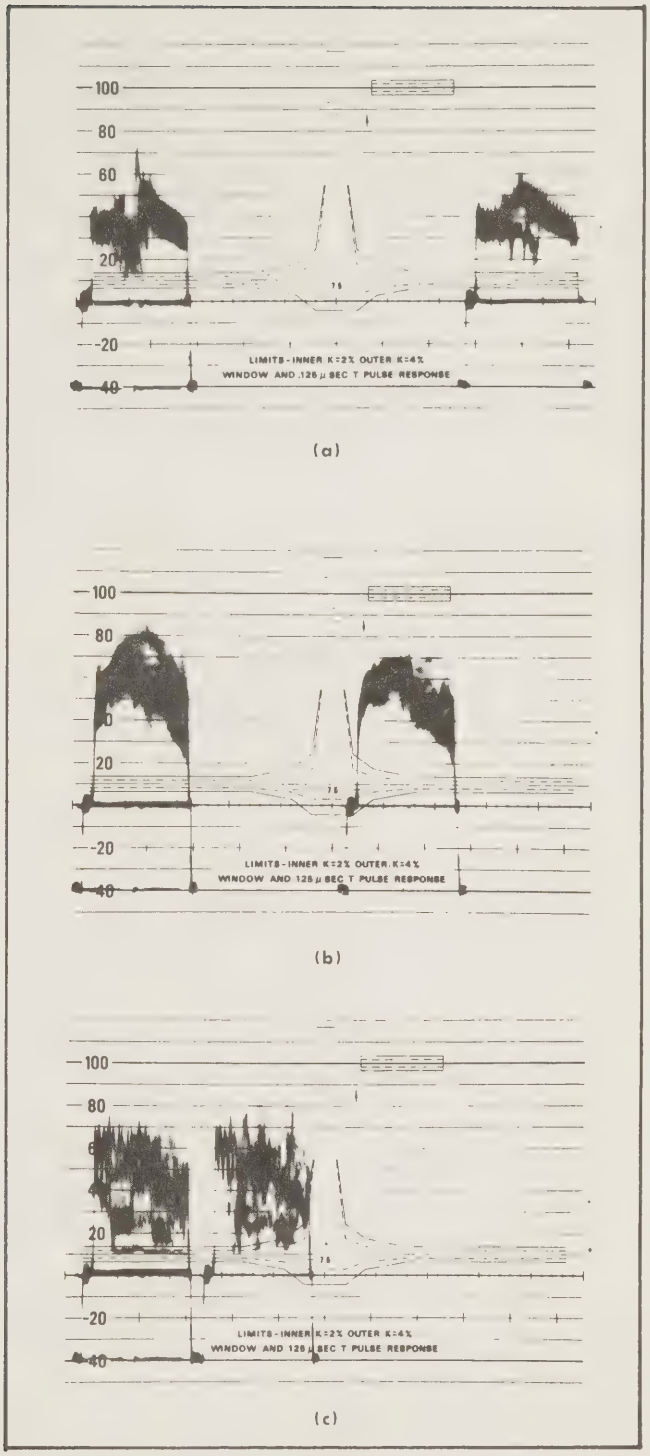

100
80
60
20
-20
40
LIMITS-INNER K=2% OUTER K=4%
WINDOW AND .128μ SEC T PULSE RESPONSE
(a)
100
80
20
-20
40
LIMITS-INNER K=2% OUTER K=4%
WINDOW AND 128μ SEC T PULSE RESPONSE
(b)
100
80
20
-20
40
LIMITS-INNER K=2% OUTER K=4%
WINDOW AND 128μ SEC T PULSE RESPONSE
(c)

Fig. 3

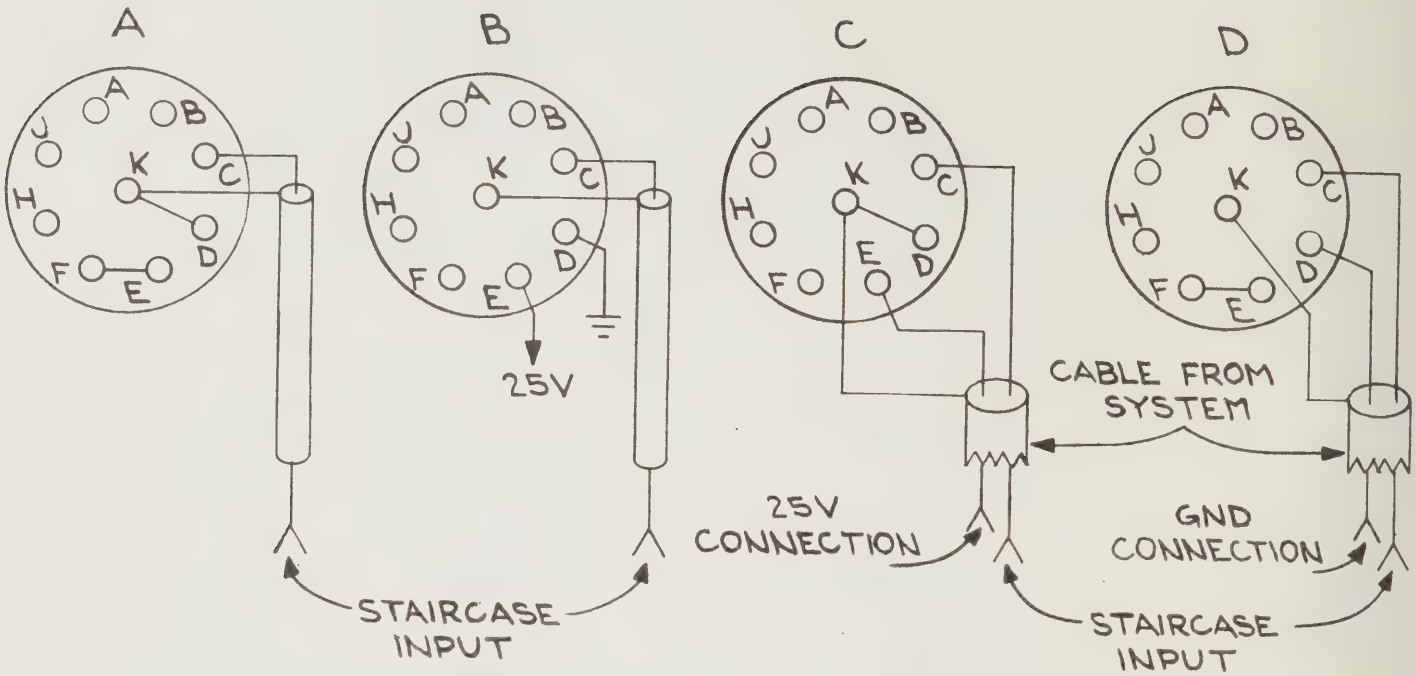


Fig. 1. Front view of 9-pin plug connector (Tektronix Part No. 134-0049-00) showing wire jumper connections to; (A) Cause relay K 385 to be energized whenever the plug is in place. (B) Energize the relay when an external voltage and ground connection are used. (C) Energize the relay when a GE system is connected. (D) Energize the relay when a RCA system is connected.

TYPE RM529

MECHANICAL PARTS LIST CORRECTION

Chassis Track assembly 351-0040-00 is divided into two sub assemblies: 351-0040-01 and 351-0040-02.

REMOVE:

351-0040-00	Chassis Track Assembly

ADD:

351-0040-01	Track Guide (left and right) (mounted on instrument)
351-0040-02	Stationary and Intermediate sections (in accessory package)

TYPE RM529 TENT S/N 1910

PARTS LIST CORRECTION

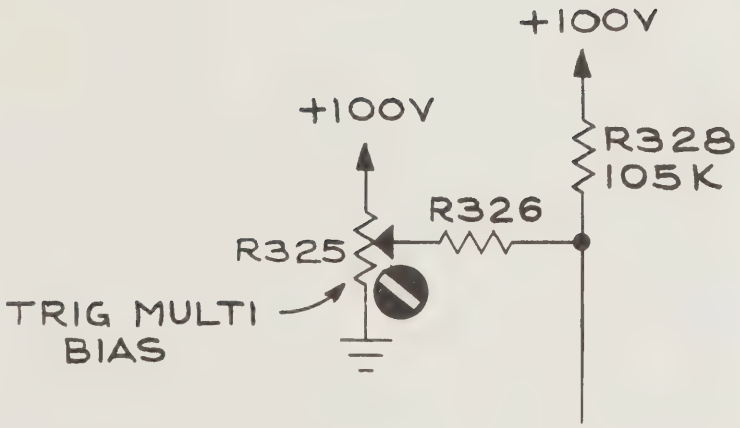
CHANGE TO:

Q325	151-0133-00	Transistor, Silicon		
Q335	151-0133-00	Transistor, Silicon		
R323	323-0346-00	39.2 k	1/2 W	1%
R326	323-0414-00	200 k	1/2 W	1%
R327	321-0297-00	12.1 k	1/8 W	1%
R333	323-0346-00	39.2 k	1/2 W	1%

ADD:

R328	321-0387-00	105 k	1/8 W	1%

SCHEMATIC CORRECTION



PART TRIG GEN

TYPE RM529 TENT S/N 1910

TEXT CORRECTION

Circuit Description:

The following should replace the description of DELAY GENERATOR and SAWTOOTH GENERATOR, page 3-9. Fig. 3-10 and the description of the BLOCKING OSCILLATOR should be deleted.

LINE SELECTOR

The Line Selector circuit includes the Delay Generator, and the Line Pickoff circuit. The selected line-trigger pulses occur once each field, an adjustable amount of time after each vertical sync pulse.

Delay Generator. The DELAY generator is normally biased so Q405 is conducting and Q415 is cut off. Q415 collector rests at +24 volts because of the voltage divider R414, R415, R418 and Q420. (The LINE selector control current from -25 volts through R428 to the junction of R418-C420 will not take the junction significantly below ground because there is 24 volts across R418 and there can be up to 25 volts across R428.) Q405 collector rests at -0.65 volt, holding Q415 base at about -6 volts by R405-R406. Q414 is saturated (collector voltage pulled down very near emitter voltage) due to base current through R417. Thus the current in Q405 emitter is set by R419 and the -24 volts at Q414 collector, and the current in Q405 collector is set by R404. The sweep generator will remain in this condition until a positive trigger pulse arrives at the base of Q415.

As a positive pulse turns on Q415, the current through Q414-R419 shifts to Q415 and Q405 turns off. As Q415 collector starts negative, C417 couples the voltage change into the base of Q414 in a direction to reduce its collector current. As the base of Q414 is taken far enough negative to almost turn off its collector current, the drop in Q415 collector voltage is nearly stopped until the current through R417 discharges C417. As C417 discharges a bit, the base voltage of Q414 turns on current a bit more. The current of Q414 is also the current in Q415 which again pulls down on C417. The result of the feedback just described is that C417 is discharged very linearly by current through R417. The voltage at the junction of C417-R417 remains essentially constant while the collector of Q415 pulls the other side of C417 negative at a rate set by the current of R417.

When the collector voltage of Q415 reaches ground level and stops going negative, current through R417 raises the base voltage of Q414 and increases its current. Increased current in Q414 pulls both Q415 emitter and base elements negative, allowing the collector to go negative too. The common emitter-to-emitter lead of Q405-Q415 drops negative until Q405 again turns on. The collector voltage of Q405 drops and quickly turns Q415 off, letting its collector voltage rise in the positive direction as R414 charges C417 to its original state. (C414 cancels Q415 initial negative collector surge caused by shifting Q414 current from about 5 mA in Q405 to about 0.27 mA in Q415. Without C414, the collector voltage of Q415 would drop sharply negative at the time Q415 was triggered into conduction.) C417 charging current is limited only by R414 since the capacitors negative end is tied to -25 volts through Q414 base-emitter junction.

TYPE RM529 TENT S/N 1910

PARTS LIST CORRECTION

REMOVE:

C424	283-0001-00	.005 µF	DISC		500 V
C427	281-0621-00	12 pF	Cer	±1.2 pF	500 V
D415	152-0185-00	Diode, 6185			
D420	152-0185-00	Diode, 6185			
D427	152-0185-00	Diode, 6185			
R420	316-0471-00	470 Ω	1/4 W	10%	
R427	315-0472-00	4.7 k	1/4 W	5%	
R436	316-0102-00	1 k	1/4 W	10%	
T420	120-0366-00	Toroid 12T, 24T			

CHANGE TO:

C420	281-0546-00	330 pF	Cer	10%	500 V
R415	323-0304-00	14.3 k	1/2 W	1%	
Q420	151-0063-00	2N2207			

ADD:

C418	281-0511-00	22 pF	Cer	±2.2 pF	500 V
C419	281-0621-00	12 pF	Cer		500 V
C422	283-0010-00	.05 µF	Cer		50 V
C423	281-0580-00	470 pF	Cer	10%	500 V
C425	283-0002-00	.01 µF	Cer		500 V
D416	152-0185-00	Diode, 6185			
D417	152-0185-00	Diode, 6185			
D418	152-0185-00	Diode, 6185			
R418	323-0443-00	402 k	Selected (Nominal Value)		
R421	316-0471-00	470 Ω	1/4 W	10%	
R423	316-0223-00	22 k	1/4 W	10%	
R425	316-0101-00	100 Ω	1/4 W	10%	

Text Correction

Reference: Text page 5-7

Delete paragraphs 2, 3 and 4 (Step 25)

Reference: Text page 5-8

Add: 27a. Adjust Common Mode Rejection (S/N 930-up)

27a Adjust Common Mode Rejection. (SN 930-up)

a. Disconnect the Type 190B from the A VIDEO INPUT connector.

b. Connect a female to female adapter to the Type 190B attenuator head and a T connector to the female to female adapter. Connect a 75 ohm coaxial cable from one end of the T connector to the upper A VIDEO INPUT connector. Connect another 75 ohm coaxial cable from the other end of the T connector to the upper B VIDEO INPUT connector.

c. Connect a 75 ohm termination to the lower B VIDEO INPUT connector.

d. Set the vertical MAG (VOLTS FULL SCALE) switch to X1 (1.0).

e. Apply 40 IRE (IEEE) units of 2 mc (MHz) signal from the Type 190B to the Type RM529.

f. Set the INPUT switch to A-B.

g. Adjust C133 for minimum display amplitude. If desired the vertical MAG (VOLTS FULL SCALE) switch may be set to provide a larger signal.

h. Recheck steps 24, 25, 26, 27 and this step several times to eliminate any interaction.

i. Remove the female to female adapter, the T connector, and the two 75 ohm cables. Remove the 75 ohm termination from the lower B VIDEO INPUT connector and reconnect the Type 190B attenuator head directly to the upper A VIDEO INPUT connector.

TYPE RM529

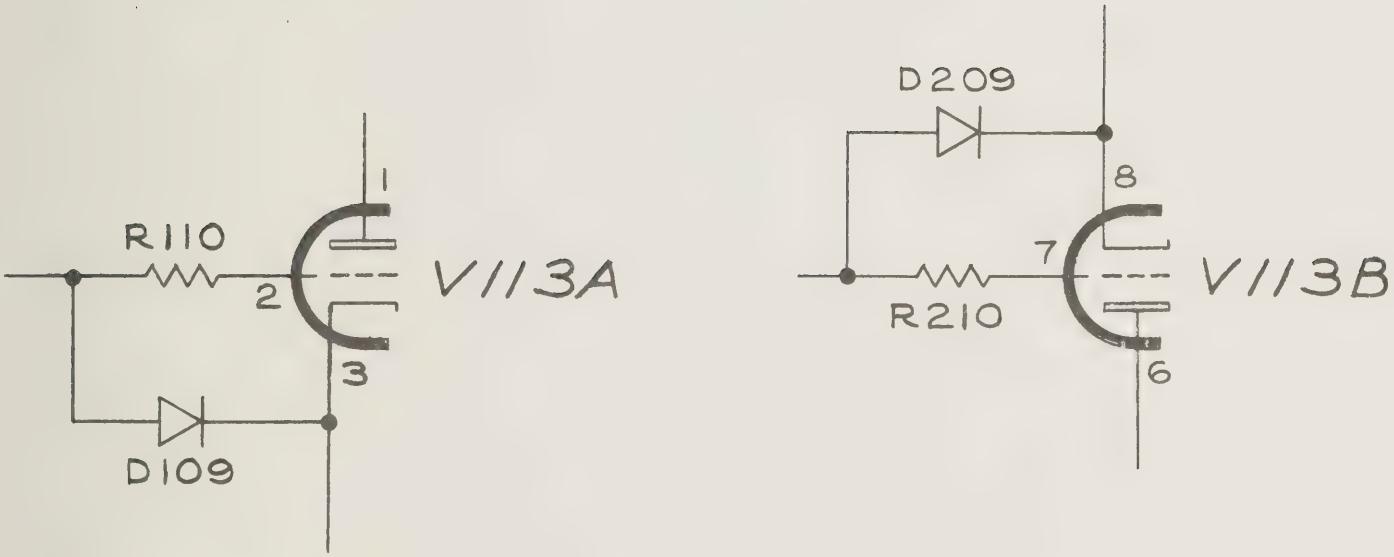
PARTS LIST CORRECTION

CHANGE TO:

D418	152-0075-00	Replaceable by 6075

SCHEMATIC CORRECTION

D109 and D209 relocated.



PARTIAL VERT AMP & DC RESTORER

Text Correction

Reference: Text page 5-5

Step 19. Adjust X25 Horizontal Sweep Magnifier Capacitor C523.

a. Set the Type 180A for 5-mc sine-wave output.

b. Set the (HORIZONTAL) MAG switch to X25.

c. Adjust the horizontal sweep magnifier capacitor C523 (see Fig. 5-10) primarily for sweep timing and secondarily for linearity. For correct timing, 16 sine waves per 10 cm should be displayed (see Fig. 5-2). For checking linearity, display should show 4 sine waves for any 2.5-cm position of the display.

TYPE RM529 -- TENT. S/N 400

PARTS LIST CORRECTION

PAGE 6-3 -- Ref. No: 1

CHANGE TO:

1	333-0863-01	1	PANEL, front

Due to the above front-panel change, it will be necessary throughout the manual to change nomenclatures as listed below.

VERTICAL:

(RESPONSE SWITCH)

CHROMA is now labeled HIGH PASS

IRE is now labeled IEEE

(MAG SWITCH) is now labeled VOLTS FULL SCALE

X1 is now labeled 1.0

X2 is now labeled 0.5

X5 is now labeled 0.2

(CALIBRATOR SWITCH)

F.S. is now labeled FULL SCALE

HORIZONTAL:

(FIELD SHIFT SWITCH) is now labeled FIELD

ODD-EVEN is now labeled ONE-TWO

(DELAY CONTROL) is now labeled LINE SELECTOR